MEMOIRS

OF THE

GEOLOGICAL SURVEY

OF

GREAT BRITAIN,

AND OF THE

MUSEUM OF PRACTICAL GEOLOGY.

ON THE

TERTIARY FLUVIO-MARINE FORMATION

OF THE

ISLE OF WIGHT.

BY

PROFESSOR EDWARD FORBES, F.R.S., &c.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HER MAJESTY'S TREASURY.

LONDON:
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LONGMAN, BROWN, GREEN, AND LONGMANS.

1856.

NOTICE.

The Session of the Government School of Mines commences in October, during which the following courses of Lectures are delivered:—

Chemistry, with special reference to its applications in the Arts and Manufactures	A. W. Hofmann, LL.D., F.R.S., &c.
General Natural History	T. H. Huxley, F.R.S.
Physics	George G. Stokes, M.A., F.R.S.
Applied Mechanics	Robert Willis, M.A., F.R.S.
Metallurgy	John Percy, M.D., F.R.S.
Geology	A. C. Ramsay, F.R.S.
Mining	Warington W. Smyth, M.A.
Mineralogy	

A Prospectus and information may be obtained on application.

Trenham Reeks, *Registrar.*

Jermyn Street, London.

I.

View of Hempstead Cliff from Sconce Point.

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The One-inch Map of the Ordnance Survey of the Isle of Wight (*No.* 10), *coloured geologically, is published, price* 3*s.* 6*d.*; *also two sheets of Horizontal and Vertical Sections.*

NOTICE.

The following description of the tertiary strata of the Isle of Wight is chiefly from the pen of the late Professor Edward Forbes, who made an important addition to our knowledge of these deposits, by showing that the beds at Hempstead, near Yarmouth, constitute the highest member of the Hampshire basin. He also first detected the existence of the fossiliferous strata near Osborne, which, filling up a vacuum in British geology, have proved to be the equivalents of certain deposits in the Paris basin.

My eminent friend was, alas! taken away from us just after he had completed his observations, leaving an outline-sketch only, which he alone could have rapidly filled up, but which required considerable additional labour when other minds were brought to the task.

Fortunately his admirers have so zealously combined on this occasion, as to bring out his MSS. on the Isle of Wight in a creditable manner.

At the head of these friends stands Mr. Robt. Godwin-Austen, who, combining the powers of a skilful geologist with his duties as an executor of the deceased, has acted as the principal editor of the work.

In a recent excursion Professor Ramsay and Mr. Bristow have re-examined the principal geological features of the Island, correcting some errors of detail and making very important additions; the results being given in the accompanying index map, notes and sections by Mr. Bristow. Some of the principal organic remains not alluded to by Edward Forbes have been described by Professor Morris,

who, for the purpose of identifying the fossils *in situ*, accompanied Professor Ramsay and Mr. Bristow. Mr. Salter, the Palæontologist of the Survey, has furnished notes on the Gyrogonites, or fossil Charæ; whilst Mr. Rupert Jones has appended a Notice on the Entomostraca of the upper Eocene formation.

By these aids the precious relic of our lamented Naturalist has I trust been rendered a lasting memento of his capacity.

RODERICK I. MURCHISON.

Geological Survey Office,
1st October, 1856.

PREFACE.

The following Memoir constitutes the first part of an essay on the comparative phenomena of the fluvio-marine and freshwater formations of different ages in the South of England, especially Dorsetshire and the Isle of Wight. During the last five years (from 1848 to 1853) a considerable portion of my time has been occupied, either in the field or in the cabinet, with an investigation of this curious and interesting subject; a research amply rewarded by not a few novel results. I propose to treat the subject under three heads:

1st. A description of the freshwater and fluvio-marine tertiaries of the Isle of Wight, and a comparison of them with their probable foreign equivalents. The part now published includes this section.

2d. A description of the Purbeck and Wealden freshwater and fluvio-marine strata of Dorsetshire and the Isle of Wight, with comparative remarks on synchronous strata elsewhere.

3d. Considerations on the freshwater and fluvio-marine phenomena of various ages, suggested by the preceding researches; with an inquiry into the geological value of the genera and species of organic remains found in freshwater and fluvio-marine deposits.

Although the inquiry into the phenomena of the Purbeck beds was first completed, for several reasons, especially on account of the want of additional data concerning the Wealden proper, I prefer sending forth the tertiary section first. In both inquiries I have derived most valuable

aid from the co-operation and advice of my colleague, Mr. Bristow.

The collection of the fossils of the Isle of Wight fluvio-marine deposits was conducted chiefly by Mr. Gibbs, whilst I was at work upon the beds; and to his ability and minute observation the greatest credit is due.

E. F.

The foregoing short outline of the plan and objects to be worked out was apparently the whole of the preface which it was intended should be placed at the head of the several Memoirs on which the author was engaged. It will readily be felt by those acquainted with the nature of the subject, as well as with the special acquirements of the author, to how great an extent his accurate knowledge of the habits and conditions of existence of marine and fresh-water forms of life, would have been made to bear upon and illustrate a wholly new branch of geological inquiry. The present Memoir was one on which he was particularly engaged at the time of his too early death, and which would have been completed had life been extended for a few weeks only.

It was my lamented friend's wish that I should take charge of all the materials he had collected for the works he had undertaken. In this I much fear that he rated far too highly my ability to fulfil all the obligations which such a wish conveyed. So far, however, as my present task is concerned, it is known to some of those into whose hands this Memoir may pass, that I had frequent opportunities of accompanying the late Professor Edward Forbes over the whole of the Isle of Wight; that I was with him when many of his notes and observations were recorded; and I may add, that I have discussed with him many points as to the

foreign equivalents of the tertiary series of this country under that new and extended range which his researches had assigned to it.

The state of the materials for the present Memoir was as follows:—there was the general outline or plan, as it is here given, together with a list of illustrations, for which sketches had been prepared. A series of six plates of fossils had been drawn on stone by Mr. Bone, and of these forms the proposed specific names had been communicated to Mr. John Morris, for insertion in the second edition of his "Catalogue of British Fossils." For the memoir itself, much of the descriptive part had been written out in full from the field note-books. In doing this the author had greatly condensed his original observations, it being his especial wish to avoid diffuseness in this part of his subject. The various tabulated results, such as those representing the distribution of species, had been in great part prepared; and, as a general guide, there was the author's Memoir on the same subject, which was communicated to the Geological Society of London, and printed in their Journal*, as also the enlarged Table of Foreign Equivalents given at p. 101.

It will therefore be seen, that so much of the Memoir on the Isle of Wight as is here given is essentially the work of my late friend, and that it is only in some few instances, and with reference to localities we had visited together, that I have ventured on supplying such short notices as were requisite to complete the grounds of his general views and conclusions. These paragraphs appear under headings which Professor E. Forbes had himself prepared. They are included in brackets. My only fear is, that these notices in some instances are somewhat too brief.

It is hoped, however, that even in its present form the Memoir will be found an useful and accurate description of

* Vol. ix. p. 259, May 4, 1853.

a most interesting part of our British area, as well as a good example of combined stratigraphical and palæontological research.

But though the present Memoir may be as full in its descriptive portion as the author himself ever intended to make it, I cannot but feel that the table of contents has the promise of several distinct disquisitions of a more speculative kind, and which, to many readers, would have been the more interesting portions of the subject. With respect to some of them, I have not been able to meet with any sufficient notes or references from which the views of the author might fairly be inferred. In matters of this kind, the duties of an editor are definite and obvious. He must not allow the recollections of views which may have been advanced in conversation to stand in the place of an author's matured and adopted opinions; nor even with respect to notes and memoranda, must he venture to take them as more than as passing thoughts, or as subjects for inquiry.

The chapter on the "arrangements, disturbances, and relations" of the tertiary formations in Britain would have been based, for the lower or earlier periods, on the views and results so carefully worked out by Mr. Prestwich, and which will be found in a communication made to the Geological Society in 1853.*

The chapter on the "Succession of Events during the Tertiary Period" would have followed naturally from the preceding one. It would have described in chronological order the formation of areas of land and water, and subordinately of seas, lakes, and lagoons, on the joint evidence of physical and stratigraphical phenomena. This section would

* On the Structure of the Strata between the London clay and the Chalk in the London and Hampshire tertiary systems. Journal of Geol. Soc., x. p. 75–170.

have had considerable extension, and was to have been illustrated by a map representing the physical geography of that portion of Europe which included and limited the tertiary seas—of what are now known as the British, Franco-Belgic, and Germanic areas.

Some of the author's views as to "foreign equivalents" will be found recorded under the heads of the several subdivisions of the middle and upper fluvio-marine series here described; these have reference more particularly to the deposits of the Paris basin.

The short reference to the condition of the surface of the Iberian peninsula was all, apparently, that had been written. We possess as yet but very little detail respecting that region. Much of its surface, during the later eocene, and also middle tertiary period, was occupied by freshwater lakes; but the relations of these to the nummulitic series beneath, and to the true Mediterranean or Atlantic miocene deposits, have not been determined.

The only other tertiary area in the south of Europe, with respect to which I can find that the author's comparisons had led him to any definite results, was that of the south-west of France. He had carefully gone over the descriptions and figures of fossil species contained in the various works of M. Grateloup, from whom he had received a complete series of all his publications; the results, however, have not been communicated to me for the purpose of this publication. The comparison of the Echinoderms of the Bordeaux district with those from the tertiary series of the Mediterranean area had evidently mainly influenced him in placing as "upper eocene" beds which at one time he had considered as of miocene age.

In 1853 Professor Forbes visited the lacustrine tertiary districts of central France, and at Clermont examined the rich collection of M. Bouillet. The species which more

particularly attracted his attention were those given below.* That this examination had reference to his Memoir on the Isle of Wight is evident from the following entry in a note-

---

* Helix depressa. Bouillet, No. 95. Is the commonest sp. at Gergovia.
„ lapicida, v. minima, No. 99, of Gergovia, &c. Is apparently distinct from the recent H. lapicida, Linn.
„ lenticula. Bouill., No. 100. Is larger, and to my eye distinct from the living sp.
„ Tristani. Brong. Is not a distinct sp. but referable to H. Moroguesi of Brong., probably the young, as suggested by M. Deshayes.
„ nemoralis. Bouill., No. 102. Is the true H. nemoralis, Linn., and is from the recent Travertin.
„ strigella. Bouill., No. 104.

Planorbis annulatus. Bouill., c. 118, of the freshwater limestone of Machal., a very marked species.
„ rotundatus. Brong. Not found with preceding; same as Headon and Hordwell species.
„ deformis, of Gergovia.
„ marginatus. Bouill. Not the recent species.
„ lens. Bouill., 116. Not the recent species.
„ contortus. Bouill., 119. Non P. contortus.
„ sparnacensis. Desh. Bouill., No. 119. All the specimens I saw were insufficient for identification.
„ spirorbis. Not the recent species.
„ nitidus. Bouill., Gergovia. An P. lens ?
„ vortex. Bouill., 121. Not it.
„ lens. Brong. Identical with Isle of Wight species.

Ancylus fluviatilis. Bouill., c. 137, of Gergovia. Is probably a very distinct species.

Paludina . . . . . ?
„ avernensis. Bouill., c. 114. About Phryganea tubes, a very marked species.
„ regularis. Bouill., c. 146.

Valvata planorbis, of Gergovia. Not it. To my eye, a Planorbis.

Unio „ of Gergovia. Very distinct sp.

Cyrena depressa. Bouill, c. 155, of the "Marbre de Nonette," with Cerithium.
„ tellinoides. Bouill., 156. Not like the Isle of Wight shell.
„ pisum. Bouill., 157. An C. depressa, *var.*, not C. pisum, Desh.

Melania inquinata, distinct from the sp. of that name.

Melanopsis „ ? Compare with some Greek species.

book made at the time :—" The general impression I derived " from an examination of M. Bouillet's large collection of " tertiary shells from the freshwater strata of central France " is, that the strata of that region are of several successive " ages, ranging down from the upper eocene period (miocene " of some French geologists) to the present. Thus much is " certain, that those travertines and marls which contain " shells certainly identical with recent species are of very " much later origin than those of Gergovia.

" The finest, best preserved, and most abundant suites of " shells which I have seen, were those from Aurillac, in the " Cantal; the next best, from the neighbourhood of Clermont. " As a whole, the Aurillac shells seemed to me different from " those of the Puy de Dôme. I saw none of the shells of the " Velay."

Taking these observations in conjunction with those which are recorded with respect to the species he had examined, it is clear that what is undoubtedly, from position, the older part of the freshwater series of central France is characterised by a considerable number of forms which have a definite place in the middle and upper tertiary deposits of the Paris, Belgian, and Hampshire basins; and further, that in the uppermost and newest travertines there is an assemblage of shells specifically identical with existing ones.

Besides these, there occurs in an intermediate position an intermediate group of forms, which have suggested comparisons in one direction with eocene species, in the other

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Cerithium Lamarckii. Cantal and Nonette.
„ gradatum. Bouill., 161, Nonette.
„ lapidum ?
Limnæa pyramidalis. Desh. Aurillac.
„ longiscata. Brongn. do.
„ ovum ? Brong.
„ fusiformis. J. Sow.
„ columellaris. J. Sow.
„ fabula. Brongn.
Velletia elegans. J. Sow. Cantal.

with existing ones. With respect to these it will be seen that Professor Forbes does not admit their identity with the shells whose names they bear. As the sedimentary series of this region is, however, a continuous one, we may fairly suppose that he intended to take the progressive change which this series of fossil forms presents as an illustration of the system of representation in time which a group of testaceous forms may present.

A short notice of the relative positions of those members of the tertiary series of south-western France had to be inserted, according to the Table of Equivalents appended to the Memoir in the Geological Journal, and in conformity with references which had evidently been prepared for that purpose.

Guided by the admirable Summary of Belgian Tertiary Geology of Sir C. Lyell, by the description of the Mainz basin by Mr. J. W. Hamilton, by the works of German geologists too numerous to cite here, it would not have been a difficult task to have completed this chapter in accordance with my late friend's views; but so great an addition would hardly have come within the range of an editor's duties.

The materials for Chapter IV. which came into my possession consisted only of the few short notes which follow, and which refer to the character and relations of the faunas of the older and newer tertiary series only.

" Fauna.	
Vertebrata.	Proboscideans, Ruminants, and Carnivora, characterizing later epoch.
	Pachyderms (ordinary) during earlier.
	Quadrumana, indicated in both.
	Birds present.
	Reptiles not very distinct from existing forms. Chelonians abundant within British area during older epoch.
Mollusca.	Few peculiar genera. Genera at present found in warmer climates greatly developed within the British area during the older tertiary epoch, and *species* of cold climates mark the close of the later tertiaries.
Radiata.	Extinct genera, marking both older and later. Temnechinus, characteristic of later. Hemiaster and Clypeasteridæ, of older.

Northern relations of British Fauna during latest tertiary epoch.
Southern and eastern relations of British Fauna during the accumulation of the Crag.

{Southern and western relations of British land during Eocene epoch. Lepidosteus. Helix labyrinthica. Glandina.
Southern and eastern ? relation of marine forms.

(But seas must have been wholly obliterated afterwards.)

General considerations respecting Tertiary Flora.
Classification of Plants.
Flowering plants chiefly found.
New classification.

Pleistocene vegetation. Northern coniferæ.
Glacial and Crag vegetation = Mid-European flora.
Miocene vegetation = Southern temperate.
Eocene vegetation :—

Upper.	Middle.	Older.
Palms.		Palms, &c.
		Nipadites, &c."

The author has recorded his opinion in the present Memoir that no sedimentary deposits of miocene age were to be found within the area he has there described. In a former Memoir he has also excluded them from the area of the Crag.

The lists of fossils given under the several subdivisions of the Isle of Wight series, have been mainly abstracted from the descriptive portions of the Memoir; some few references have been added. In the preparation of these lists I have to acknowledge the very great assistance I received from my friend Professor J. Morris. The typical forms, which served either for comparison with described species or for the establishment of new ones, will be found in the collection of the Museum of the Geological Survey. My personal thanks are, I feel, specially due to Professor Ramsay, Mr. Salter, and Mr. Bristow, for their kind and valuable co-operation in the work entrusted to me.

Robert Godwin-Austen.

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Isle of Wight Fluvio-marine Tertiary Formations.

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THE TERTIARY FLUVIO-MARINE FORMATION

OF THE

ISLE OF WIGHT.

Superficial Accumulations of Later Tertiary Age.

Although the present Memoir relates mainly to the fluvio-marine division of the older tertiary series of the Isle of Wight, it is necessary that such deposits of later date as occur within that area should be noticed, in order that the relations of the older series to the present contour of the surface may be clearly understood. The superficial deposits consist of sands, clays, and gravel, all of post-eocene date, but belonging to two or more stages of a long and important period, which may be designated Later Tertiary; the history of this period constitutes a subject of the highest geological interest and importance, and as yet is only in the infancy of treatment. Many years must elapse before we can hope to approach the solution of the exceedingly complicated problems which this stage of the earth's history presents; in the meantime, every contribution in the shape of minute and local observation has its value, and the few notices here given may prove not without their use.

There are no strata in the Isle of Wight or on the opposite coast of Dorsetshire or Hampshire that can be referred definitively to the miocene or pliocene epochs. What the possible dates of the older superficial deposits here noticed may be, is a question on which a few remarks will be offered in the sequel.

Taking all the deposits of post-eocene age to be observed within the area of the Isle of Wight, their classification may be as follows:—

I. Beds now forming, or of recent date.

II. Newer and lower gravel, clays, sands, &c.; under this head we may include,

1. The Elephant gravel of Freshwater Gate.

2. Sands and gravel of the combes on the south coast of the Isle of Wight (and Dorsetshire).
3. Gravel of Foreland and St. Helen's.
4. Hazel-nut sands and peaty beds beneath gravel of south and west coast.
5. Subaërial and lacustrine superficial beds of Tollands Bay.
6. Gravel in the valley of King's Quay.
7. Brick-earth of Wootton Creek.

III. Older and higher gravel :—

1. Gravel and conglomerates along the line of Chalk Downs.
2. Gravel on top of Headon Hill.
3. Gravel of the high levels and hill tops along the northern coast and north of the chalk in the Isle of Wight.

II. 1. *The Gravel of Freshwater Gate, with Elephants' Remains.*

[These gravel beds are well exhibited in the cliff sections of Freshwater Bay, and are interesting and instructive, as they show most clearly that superficial accumulations such as those which cover so large a portion of the surface of the Isle of Wight, and which to the casual observer would hardly seem capable of subdivision, are yet separable into groups referable to very distinct periods of past time.

Freshwater Gate is situated in the most western of the several transverse depressions which the range of the highly inclined chalk strata presents in its course through the Isle of Wight; and the only difference to be remarked upon is this,—that the Freshwater depression is the deepest of these, extending down to the present sea level. The higher portions of the chalk range, as Beacon Down on the west, and Afton Down on the east, present only a thin coating of angular flints, the residue of that portion of chalk which has been dissolved away. These downs are good illustrations of the rate of waste over calcareous surfaces from the action of rain-water alone. Detritus and gravel beds occupy the lower slopes, as shown in woodcuts Nos. II. and III.

On the west side of the valley (Vignette III.*) the superficial beds reach a considerable elevation, descending thence continuously to the sea level. Starting from this lower line, it will be seen that the gravel beds which rest immediately on and against the chalk are composed of coarse sub-angular and water-worn flints, with chert and ironstone from the lower cretaceous beds; the whole coloured and somewhat cemented by iron. The lower gravel beds conform to the irregular surface of the chalk, but higher up the mass has a marked horizontal arrangement, with occasional bands of coarse sand. These lines of successive accumulation, when traced out towards the valley, end abruptly along a line which slopes at an angle of 30°, and which is distinctly marked through a vertical height of 14 feet.

The bed which follows next on this slope is rather more than a foot in thickness, and agrees so completely with the gravels against which it rests, that it could not be distinguished from it but for the arrangement of the materials, which is in accordance with the slope.

The diagonal bed here described separates the dark gravel from another horizontal series, which is very distinguishable, both by colour and composition. The materials are generally finer, and the thickness and number of the sand beds greater. These last, more particularly in the lower portion, show the cross-bedding which is produced by drifting currents having opposite sets at different times. There occurs throughout this newer gravel a considerable admixture of small rounded detritus of white chalk, which is wholly wanting in the older gravel.

After the newer series had been raised to the level of the older one, it appears to have spread out over it. This portion, which is not thick, resembles the older gravel in coarseness and the newer in colour, and consists, in fact, of the re-arranged surface of the older gravel beds.

These accumulations are overlaid by the brick-earth deposit, which contains here, as elsewhere, the usual disseminated fragments of angular flint.

* The modern buildings and new fort have been omitted in this sketch.

The newest bed to be here noticed is that which occurs in superposition on the foregoing, along a line at the base of the

Freshwater Bay, from the West.

II.

Chalk hills. It consists largely of chalk rubble and detritus, with angular flints. It has a marked banded arrangement,

conforming to the slopes above it, of which it is the talus. It must not be confounded with the underlying gravel beds, and considered a continuous portion of them, as has sometimes been done elsewhere.

The newer gravel series has been cut out along the central line of the valley, just as the older ones had been at some earlier time.

The superficial deposits of the east side of the valley (Woodcut II.) do not correspond exactly with those on the west. The removal of the older or red-gravel series has taken place to a much greater extent, and the bulk of the mass consists of the newer gravel and brick-earth series, together with the sub-aërial talus. The brick-earth beds here contain *Succinea oblonga* and *Pupa muscorum* somewhat abundantly.

The Elephant remains found at Freshwater consist of two molar teeth, of which the first was met with on the west side of the valley, in an excavation on the site of the lower hotel, and where the specimen is now preserved; the other was procured from the beds on the east side. These remains are referable to the newer gravel series.]*

III.

Freshwater Bay, from the East.

* See note by Mr. Bristow, p. 103.

3. *Gravel Beds of Foreland and St. Helen's.*

[At the east end of the island, as along the Whitecliff Bay section and on to Foreland Point, it will be seen that an apparently continuous bed of gravel is spread out over the surface. The gravel does not reach the level of the chalk, and where it is first met with, resting on the edges of the vertical lower tertiary strata, it is at most only a few feet thick. At Foreland Point the gravel beds come down to the sea level, when the dimensions of the mass are very considerable. The materials are principally chalk flints, but there are also blocks of grey wether sandstone, with chert and sandstones from beds below the chalk; these are often of large size, and the whole is much water-worn. There is a distinct arrangement to be observed indicative of successive accumulation, with occasional bands and seams of drift sands.

If the gravel beds on the side of St. Helen's are a continuation of those of Foreland, there is a diminution of thickness with the rise of the tertiary strata on which they rest. It would, however, be very difficult to refer them to different ages, and the whole may be considered as possibly referable to a period subsequent to the formation of the Peat beds to be next noticed, and as having been accumulated during the time that the Isle of Wight underwent a movement of *depression*, as compared with the level it now has.

If the gravel beds of Foreland had a true horizontal arrangement at the time of their accumulation, it would seem as if the depression of surface which admitted of that accumulation was progressively greater from south to north, whilst the subsequent rise, which has placed them in their present position, must have been somewhat in the contrary direction, or on the north, for the Foreland mass has a very distinct southern slope.

I am not aware that any Mammalian remains have yet been found in these gravel beds, and until such should occur their age must be very uncertain. There are many considerations according to which the gravel beds of Foreland

cannot be separated from those which cap all the hills of the northern portion of the island.]

II. 4. *Hazel-nut Sands and Peaty Beds beneath Gravel Beds of South and West Coast.*

[The earliest notice of the preservation of an old land surface beneath a portion of the gravel beds of the Isle of Wight is contained in Sir H. Englefield's History of the Island, and which is so accurate, that I cannot do better than adopt his description:—

"Near the top of the cliff (Brook) lie numerous trunks of trees, not lodged in the undisturbed strata, but buried 8 or 10 feet under sand and gravel. Many are a foot or 2 feet in diameter, and 10 to 12 feet in length; their substance is soft, but their forms are distinct; and with them occur considerable quantities of small nuts, like those of the hazel." —p. 132.

The position of these beds is shown in Plate 22 of Sir H. Englefield's History.*

Near Bembridge Point, and at the sea level, there is a section, which is the exact counterpart of the one above described.

The lowest bed consists of the tertiary clay; above this, and in an uneven surface, are gravel beds; those on the left of the section are much mixed with sand, with rounded and angular blocks, whilst the mass on the right is finer. The upper surface of the gravel is uneven, and supports a bed of peat, with seams of sedimentary matter; in these beds hazel-nuts are abundant, together with the remains of beetles.

The sedimentary beds pass gradually up into sands and clays, with angular flint gravel.]

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* See note by Mr. Bristow, p. 103.

II. 5. *Subaërial and Lacustrine Superficial Beds of Tollands Bay.*

These were first noticed by Mr. Trimmer, and described by him in a communication to the Geological Society of London (Journal Geol. Soc. x. p. 54). They occur at the base of Headon Hill, and may be seen in the cliff section in Tollands Bay, where they form a horizontal deposit of limited extent, about 60 feet above the sea.

The uppermost portion consists of brown loam, with disseminated fragments of flint and of eocene freshwater limestone; it is the equivalent of the "brick earth" of the Isle of Wight, and at this place varies in thickness from 1 to 5 feet. Beneath this the deposit is mainly calcareous, consisting of marls and tufaceous bands, with seams of sand and clay, blackened by vegetable matter.

Land shells (Helix arbustorum or nemoralis, Cyclostoma elegans) are distributed throughout the whole deposit; Succinea oblonga occurs sparingly.*

This deposit of an old freshwater pond presents, in descending order,—

1. Loam, with scattered Helices, fragments of flints, 6 ft.
   Helix arbustorum or nemoralis, Cyclostoma elegans, abundant.
2. Clay bed more full of shells,—
   Limnæa palustris, Helix pulchella, H. ericetorum, H. hispida.
   Zua lubrica, Achatina acicula.
3. Bluish carbonaceous marl, shells most plentiful, 2 ft.
   Succinea oblonga, Cyclas.
4. White tufaceous marl, sandy in places, becoming purplish towards base, and somewhat stratified, 3 ft. 8 in.
   Cyclostoma elegans, Clausilia, Succinea oblonga.
   Cyclas or Pisidium, Helix hortensis, H. rotundatus, H. cellaria.

* This deposit, according to Mr. Trimmer, was found by Professor E. Forbes to contain shells of the genus Unio. Vide note 3. p. 105.

Bands of concentric concretions of lime occur, and occasionally sharp angular fragments of flint.*

II. 6. *Gravel of the Valley of King's Quay.*

In the bed of the streamlet that flows into the creek at King's Quay, between Osborne and Wootton, close to the bridge on the road from Ryde to East Cowes, a small section is exposed which exhibits a surface of pale blue and yellow eocene marls, capped by a rough flint gravel. The flints are for the most part of considerable size, and are rounded.

II. 7. *Brick-earth of Wootton Creek.*

Along the western side of Wootton Creek, on the slope of the banks, are considerable deposits of rich umber-brown sandy clay, with scattered, small, and but slightly worn fragments of flints. This clay is of considerable thickness in places, varying from 6 and 8 to 20 or 30 feet. It shows only very slight evidence of successive deposition; it extends to a height of 30 feet or more up the slope of the hill, and appears to be distributed in extensive patches. It ceases altogether before the lower edge of the gravels that cap the hill above is reached, the interval being occupied by eocene clays. Patches of brick-earth occur also, though apparently more sparingly, on the eastern side of the creek; it may be seen along the edge of the shore of the Solent at Fish-house, at the eastern angle of the creek, but has not as yet been noticed as occurring in any other part of the island. It is highly prized as a brick-earth, and has been of late in requisition for the bricks used in the new fortifications at Sconce.

No mammalian remains have as yet been noticed in this deposit.

III. 3. *Gravel of the hill-tops along the North Coast.*

The road from Ryde to East Cowes undulates over a series of steep hills and deep valleys running at right angles to the Solent. Whenever the slope of the hill has been left nearly in its natural state, at some 20 or 30 feet from the

* See note by Mr. Bristow, p. 105.

summit the ascent becomes suddenly steeper; this feature marks the thickness of the mass of gravel capping these hills.

Similar gravel beds are to be seen in the opposite direction, between Ryde and St. Helen's. They occur also between West Cowes and Yarmouth (as on the summit of Hempstead Hill), as also on elevations in the inner portion of the tertiary district (Parkhurst Forest).*

These gravel beds consist for the most part of angular flints much broken, with occasional patches and seams of sand; the flints are used for mending the roads, not always with the best discretion. Though the series presents numerous and extensive gravel pits, the occurrence of mammalian remains has not yet been noticed.

Relation of the Valleys to Gravel Beds and Disturbances.

To determine and classify the dates of the hollows and valleys over the surface of the Isle of Wight, or elsewhere, would require minute, laborious, and often repeated examinations, such as would be the work of years if fully and fairly done. At present it would be rash to venture on more than an indication of certain differences that seem to imply distinctions of age, of origin, and mode of formation, of the sulcations of the surface of the island. The superficial conformation as it is at present exhibited, with the exception of the features dependent on the great disturbances and foldings of the cretaceous and eocene strata, seem mainly to take date subsequently to the spread and deposition of the higher gravel, themselves distributed after the verticalization of the chalk, and consequent rolling of *all* the eocene strata.

Before the deposition of the older gravel the surface appears to have been one of gentle undulations; after that epoch it became scooped out into valleys, especially along the southern and western sides of the cretaceous axis. These are the combes and hollows in which we find the lower gravel, brick-earth, and equivalent beds.

The creeks of Wootton and King's Quay, and the gravel-filled excavations on the eocene beds at Foreland and the Priory below St. Helen's, are of the same class. Some of the

* Also between Combley Farm and W. Standen. H.W.B.

valleys in which ancient gravel beds have not been noticed may possibly be of the same date, but the majority of them may be referred, provisionally at least, to a different and later class, and to owe their conformation mainly to the action of streams, and atmospheric causes. The valley of the Medina, as will be shown, is due to a considerable fault, affecting both the chalk and eocene formations; and it is very possible that the peculiarities of the valley of Freshwater are due to a like cause; it is not improbable that both these valleys are of more recent date than those occupied by the lower gravel and brick-earth, and that the faults which affect them are of comparatively later date.*

The higher gravel beds of the Isle of Wight are probably coeval with the higher gravel of the valley of the Stour (Dorset). I visited this district in company with Mr. Bristow, who directed his attention especially to the gravel of the vicinity of Blandford, which is well seen in a pit in the nursery ground above the town, at an elevation of about 50 feet above the Stour. It is there from 6 to 12 feet thick, and consists of angular and much broken flints, mixed with small rolled gravel, and interstratified patches of sand. Mr. Shipp of Blandford possesses a fine collection of elephants' teeth, collected by himself from this locality. The teeth of the horse also occur. Similar gravels are seen at Winterbourne and Thompson.

The surfaces of the Chalk Downs are free from gravel. On the slopes of the valley of the Stour, and at a lower level than the elephant gravel just noticed, there occurs a rich loamy gravel, consisting of whole or partially broken flints. This newer gravel is probably the equivalent of the lower gravel of the Isle of Wight, and was deposited after a gently undulating surface had been furrowed into deep valleys, in the present instance now occupied by a river bed.

The dry scoop-shaped hollows called "combes," along the Dorsetshire coast, excavated in the chalk, Portland sandstone, Kimeridge clay, and other strata, are often converted into rabbit warrens, from the facility with which these animals

* See notes by Mr. Bristow, pp. 117 and 123.

are enabled to burrow into the sands and fine gravel which line their sides and bottoms. These deposits are of the same age with the slopes and combes in the southern and western coasts of the Isle of Wight. I noticed the occurrence, in the Dorsetshire deposits, of numerous flattened stony fragments, consisting of a purple ferruginous cement, enclosing minute white and yellow angular splinters of flint, giving to such fragments, at first glance, the aspect of pieces of porphyry. These I subsequently identified with the ferruginous layers found in situ in the upper and older gravel of Headon Hill, and hence infer that the Dorsetshire gravel beds have been derived from the breaking up of a like older series.

The late Lord Eldon, when making improvements at Encombe, obtained from the gravel of that hollow numerous mammalian remains, including Elephant, Bison, and Deer.

Introductory Review of the Geology of the Isle of Wight.

[§ 1. The present somewhat rhomboidal form of the Isle of Wight is partly due to the unequal action of the sea on its coast-line, and partly to those disturbances which have thrown some of its component strata into those remarkable positions which form the features of the well-known scenery of Scratchells, Alum, and Whitecliff Bays. Freshwater and Sandown Bays are due to the rapid waste of the cliffs of the lower green-sand and Wealden beds, as compared with those of the chalk.

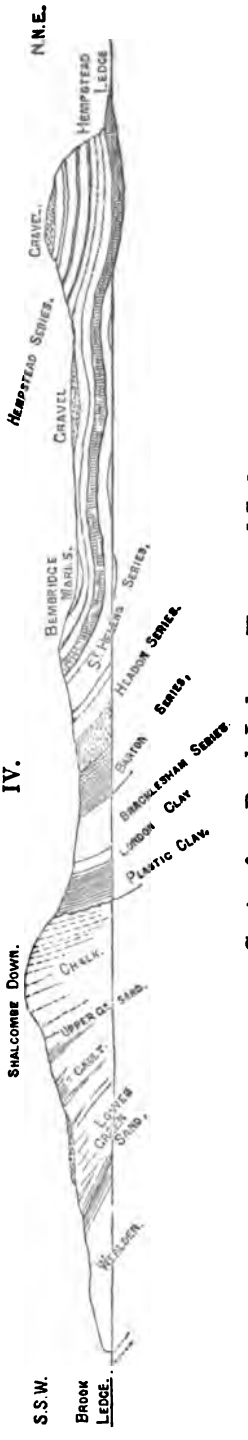
The leading physical feature in the structure of the Isle of Wight consists in the ridge of high and bare chalk downs extending from the Needles to Culver Cliff, and having an irregular course from east to west. Towards both extremities of the island the chalk range contracts in breadth, whilst the beds are much more highly inclined; in the same directions also the elevation of the ridge diminishes.

There is another range of chalk strata in the south, extending from St. Catherine's Down on the west to Boniface

Down on the east; the whole of this mass has a slight southerly slope, with a direction from E. 6° N. to W. 6° S. In the interval between these two masses the complete succession of the lower Cretaceous and lacustrine Wealden groups is exhibited.

The chalk ridge of Brading and Bembridge Downs trends W.N.W., E.S.E., so that on the east end of the island the two ridges converge rapidly; the submarine course of the chalk strata can also be traced for a considerable distance, and serves to define the elliptical form of the disturbance on the east of the island. This arrangement of the chalk strata, taken in conjunction with the structure of the Wealden area of Kent, Surrey, and Sussex, and with the synchronous disturbances which extend thence westwards, refers the Isle of Wight area to the great linear series of elliptical elevations and denudations of the south of England. The central ridge is depressed and cut through at places by transverse valleys, as at Freshwater Gate, Shalcombe, Calbourn, and by the Carisbrook, Medina, and Brading valleys. All these breaks may possibly be on lines of fault, like that of the Medina, where the displacement of beds once continuous has taken place both vertically and horizontally.

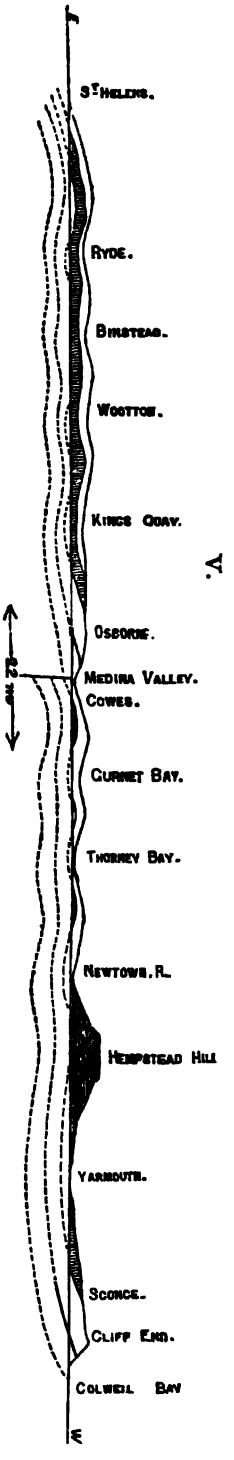
§ 2. The part of the Isle of Wight which lies to the north of the central chalk range is composed entirely of older tertiary strata. The disturbances which these present resolve themselves into



Section from Brook Ledge to Hempstead Ledge.

two series of undulations, of which one set, and the most strongly marked one, has an east and west course, as shown in woodcut No. V., which represents in a general way the character of the undulation at the places indicated. In this section the band with vertical lines indicates the Bembridge, Binsted, and Sconce limestone, which from its uniformity and characteristic contents is most easily identified, and which, with the mass of strata in Hempstead Hill, constitute that upper portion of the tertiary series of deposits which it is the principal object of this Memoir to describe and illustrate.

The undulations which are here projected on a straight line are such as are presented on the coast from St. Helen's to Colwell Bay. Each of these curves can be traced across the northern or tertiary portion of the island, and has a corresponding line of curvature in the central chalk ridge. These undulations are accompanied by numerous faults or dislocations; but the only one which, from its magnitude, deserves special notice, is that indicated as occurring along the line of the Medina valley, the character of which disturbance, as it passes through the chalk formation, has already been noticed.



V.

Fault of the Medina Valley.

The beds which occur at West Cowes belong to that division of the fluvio-marine series of the Isle of Wight, for which the name of "Bembridge marls" has been taken in this Memoir, and which follow next on the Binsted limestone. At the time when I communicated the

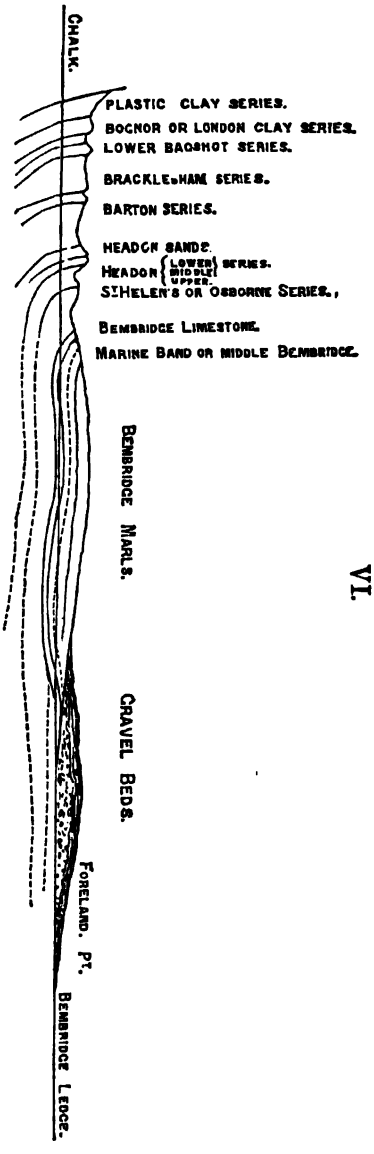
result of my researches in the Isle of Wight to the Geological Society of London, in May, 1853, I supposed that the same series was continued on over the whole of the north of the island as far as St. Helen's, and that the valley of the Medina was one of depression. It was shortly after a lecture I delivered at the Royal Institution, in the same year, "On some New Points in British Geology," that a collection of fossils, obtained within the demesne at Osborne, was communicated to me from His Royal Highness Prince Albert, whereby I became aware that much lower portions of the tertiary series were exhibited on the east side of that valley. The results of a detailed examination, which I obtained permission to make, were—that several of the subdivisions of the tertiary series, which occur beneath the Bembridge limestone, emerged in succession at this place, and that thereby a fault of considerable magnitude, coincident with the line of the valley, was clearly indicated. Owing to the clothed surface of the ground, the phenomena here described can only be seen in the coast section. The valley of King's Quay is one of depression, presenting an upper surface of marls, resting on Bembridge or Binsted limestone. The beds of this stone rise to the surface on the west, and are followed by a series intermediate in mineral character between those which are to be seen on the west—as at Cliff End, next beneath the Sconce limestone—and those beds on the east at St. Helen's, which are of the same age. It is with the series of the east end of the island that we must compare the Osborne beds.

The first or highest beds which rise from the shore, near the landing-place, consist of the St. Helen's sands; from beneath them the Nettlestone grits appear at the boundary of the grounds of Norris Castle, overlying the "Upper Freshwater" series of Headon Hill and Colwell Bay.

From the known thickness of these several groups, the amount of displacement which has taken place on the line of fault between East and West Cowes may be estimated at more than 200 feet. This fault apparently diminishes in amount from north to south; the curvature of the beds also is less in the same direction. The form of the north coast

of the Isle of Wight, which presents an advance of the land on each side of the line of the Medina, is due to this disturbance. [See also the description of the Section at p. 14.]

[§ 3. The longitudinal undulations affecting the tertiary strata on the north, or those which run parallel with the chalk ranges, are less obvious than those above described. If we except the first great abrupt flexure of the beds in immediate sequence from the chalk axis, the nearest sections present only depressed and extended undulations. The character of one of these is exhibited in Whitecliff Bay on the east (Woodcut VI.), and another is indicated on the section drawn from Brook to Hempstead Ledge (Woodcut IV.). This order is the very reverse of what has happened with respect to the transverse set of faults and undulations, and may serve to indicate the nature of the forces which have produced the disturbances of the area under consideration.



VI.

The illustrations which accompany this section of the Memoir will sufficiently explain the structural as well as geological relations of the series of deposits of which the Isle of Wight is composed. Apart from the two sets of undulations which have been here noticed, the general structure of the island has been beautifully illustrated by Mr. Webster and Sir H. Englefield, and more

recently by the popular work of Dr. Mantell.] [Geological Excursions, &c.] It will thus be seen that the contour of the Isle of Wight depends on the gentle rolling of its component strata in two directions, the one series of rolls being parallel with the E. and W. chalk ridge, and the other at right angles to it. The E. and W. undulations are connected with the movement that elevated the chalk vertically; the N. and S. ones also affect the chalk, since each north and south valley, formed by the synclinal curve of a roll, corresponds to the division between two chalk downs, and each down to an anticlinal.]

All the lower tertiary strata, including the fluvio-marine beds, are affected by these movements.

The gravel beds which rest upon the tertiary strata, whether the oldest or higher level gravels, or the newer, such as those which occupy the combes and transverse valleys, or that form thick masses, as at Foreland, are unaffected by these movements.

§ 4. As numerous memoirs by eminent geologists, British and foreign, had been published on the geology of the Isle of Wight, I did not expect, when I was directed by Sir H. De la Beche to examine the distribution of organic remains in its various strata, that it would have offered so much of what was both geologically and palæontologically new, that even the structure of a considerable portion had been misunderstood.

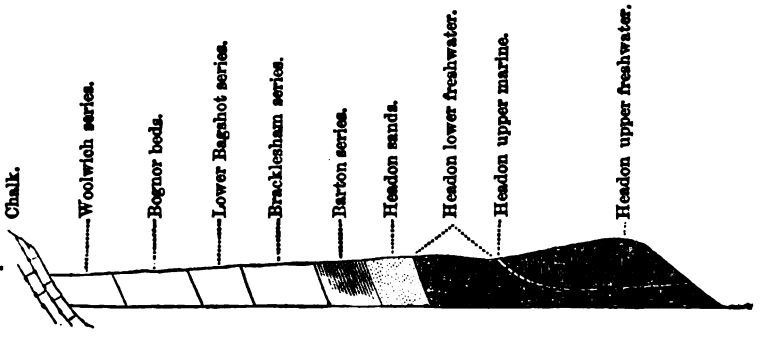
The interpretation which had been usually accepted respecting the structure of that part of the Isle of Wight composed of fluvio-marine eocene beds, and which constitute the greater portion of the island north of the chalk range, is, that the series of beds exposed in the section of Headon Hill, and constituting the Headon Hill sands, Lower Freshwater, Upper Marine, and Upper Freshwater groups of Mr. Webster, includes the whole thickness of the fluvio-marine series, and that the greater part of the tertiary superficial area is occupied by the Lower Freshwater division.

This view, which originated with Mr. Webster, was supported and maintained in detail by Professor Sedgwick, and

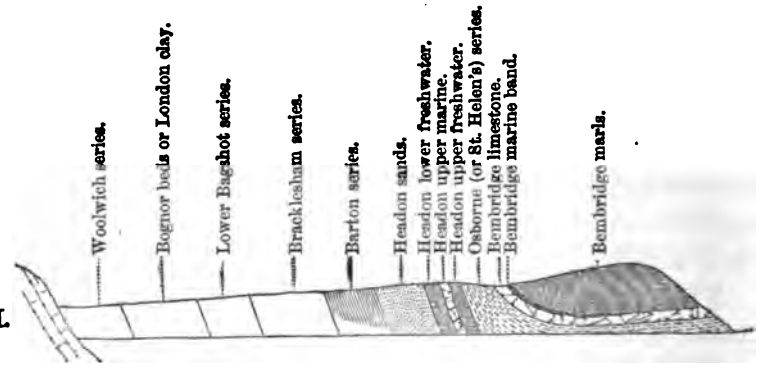
has been adopted by most subsequent writers. Two geologists only, as will be seen in the sequel, have surmised the existence of a higher series than is to be found in Headon Hill, namely, Mr. Prestwich and M. Hébert.

All geologists, without exception, who have compared the section at Whitecliff Bay, at the east end of the island, with that of Headon in the west, have regarded the fluvio-marine series in the former place as the equivalent of that in the latter. No one seems to have suspected that the fluvio-marine beds as Whitecliff were in considerable part superior to those of Headon Hill. The new reading which my examination has enabled me to arrive at, as compared with the one which had been previously received, is best represented by the subjoined diagram sections. [Woodcuts VII. and VIII.]

VII.



VIII.



The well-known mammaliferous limestone of Binsted and Seafield had always been considered the equivalent of some of the Headon beds, usually as representing the Lower freshwater limestones, whilst the occurrence of a marine or brackish water band next above the true Bembridge limestone of Whitecliff Bay tended to confirm this view.

Analysis of previous Papers on the Isle of Wight District.

Mr. Webster.

The first, and, taking all circumstances into consideration, the best general account of the fluvio-marine formations of the Isle of Wight is contained in the remarkable letters by the late Professor Thomas Webster, printed by Sir Henry Englefield in his beautiful work on the Isle of Wight, published in 1816. In the preface to this valuable volume, the expression "that part of natural science lately called geology" singularly contrasts with the able and advanced examples of geological research that follow. The observations of Mr. Webster were made in the years 1811, 1812, and 1813. Letters xi. and xii., respectively dated "August 2d, 1812," and "February 11th, 1813," especially the latter, chiefly concern the strata under our consideration. In these, the "freshwater formation" of the Isle of Wight is compared and identified with the freshwater beds of the Paris basin. Headon Hill is taken as a type, "the lofty cliffs affording the finest natural sections, and exhibiting a great variety of strata" (loc. cit. p. 227). The lowest is stated to be "a very white sand, which is employed in the manufacture of glass. Immediately over this is one of very dark blue clay, without shells. On this rests a series of beds of sand and sandy marl, with a good deal of a brown coaly substance.

These contain vast quantities of shells, chiefly in fragments, but which prove to have been entirely of freshwater origin. They belong to the *Planorbis* and *Limnæa* of Lamarck. Over these beds is a very thick stratum of a greenish marl, which contains an immense quantity of fossil shells, many of which are in perfect preservation. These are entirely marine. The stratum over this consists of the calcareous rock which I formerly mentioned to have been employed here in building, together with a friable calcareous marl, both of which contain prodigious numbers of fossil freshwater shells. Many of these are quite perfect. They consist of several species of the *Limnæa* and *Planorbis*, exactly corresponding to those described by Lamarck in the basin of Paris; and they agree, in genera at least, with the recent freshwater shells of this country. It is with the casts of these shells that the stone of Bembridge and Gurnet is filled. Over this considerable stratum of calcareous rock and marl there is a thin bed of blue clay, with many fragments of shells, and also one of calcareous sandstone without any shells. This is covered by another bed of calcareous concretions, containing a few freshwater shells; and this last bed, which is the termination of the series, is extremely hard and dense, and some parts have even a porcellaneous character. A very thick bed of flint gravel forms the top of the hill. All these strata may be distinctly traced along the cliffs of Headon and quite to Tollands Bay, which, together with Colwell Bay, is covered by the lowest bed of fine sand. The whole series, however, can only be seen at Headon. In the other parts of the western, as well as the northern parts of the island, only portions of the series remain; so that, to understand them, it is necessary first to learn their characters at Headon."

In his table of strata, Webster, guided by the supposed analogy of the Paris basin freshwater beds, divides these strata into the upper freshwater, the upper marine, and the lower freshwater formations; distinguishing from the last the "sand without shells." He refers the limestone at Gurnet Bay, "although more calcareous and more indurated

than that of Headon," (loc. cit. p. 231,) to the Lower freshwater, and notices that there are several beds of this limestone alternating with clays and containing gyrogonites. At West and East Cowes he refers strata, forming mouldering slopes, and occasionally "containing alternating beds of marine shells," to the lowest freshwater formation. "Over this may be distinguished, though in ruins, the upper marine formation, by its numerous fossil shells." In the grounds of Lord Henry Seymour he notices a siliceous limestone, called "Rag," and containing *Helix vivipara* and other freshwater turbinated shells. Between Cowes and Ryde he observes marine fossils "such as Cerithia, Oysters, and Cytherea" in blue clay. The stone of Binsted he refers to the "lower freshwater formation; and blocks of calcareous stone containing *Limnæa* lying on the top in a detritus consisting of blue clay," he considers analogous to the rock forming the Upper freshwater formation at Headon. He remarks the occurrence of the "fragment stone" of Binsted along the shore eastwards, and of the rock with *Limnææ* at Bembridge. Hence it would appear that he considered the limestone at Bembridge as probably equivalent to the higher freshwater limestone of Headon. He refers the stone worked near Calbourn and elsewhere in the interior to the Upper freshwater formations, he observes the upward curve of the Bembridge limestone at Whitecliff, and notices the remarkable superficial gravels and clays of the peninsula of Bembridge.

It is quite clear that Webster considered Headon Hill as exhibiting the maximum thickness of the fluvio-marine formation; that in no other part of the Isle of Wight was such a display of these strata to be seen, or indeed the uppermost of them present; that the limestone masses in other parts of the island belonged either to the Lower Headon or to the Upper Headon beds, strictly so called; and that wherever he saw marine shells in the fluvio-marine strata, he referred them to his "upper marine," that is, the Middle Headon beds. Although he noticed marls and calcareous strata near the summit of Headon Hill, that

really belong to our Bembridge and St. Helen's series, it is evident that he did not identify the beds that attracted his attention elsewhere with these, but with beds lower down. He noticed the peculiarities of the strata to the eastward of Ryde, but did not discover then their true homologies. This is all said without the intention of any disparagement to Webster or his labours. The short time in which he made the admirable observations cited above, and the early stage in the history of British geology when they were made, renders only more surprising the accuracy and fulness of the majority of his statements, and strongly impresses the geologist who works with care over the ground first explored by Webster, that that remarkable man was not only a pioneer in research, but also one of the very ablest of British philosophers.

Professor Sedgwick.

In May 1822, a valuable paper, by Professor Sedgwick, "On the Geology of the Isle of Wight," was published in the 19th volume of the Annals of Philosophy. Particular attention was directed in this memoir to the fluvio-marine beds; and several important localities, especially that of Hempstead Cliff, were for the first time described. The author regarded all the vertical strata of Whitecliff Bay as inferior to the Lower freshwater, placing among them (with accurate notices of their contents) the strata which I shall prove to be identical with the "Upper marine" or Middle Headon Beds, with which, as it occurs in Colwell Bay, Professor Sedgwick indeed observed the analogy, and remarked that all the species found in these beds in Whitecliff, with the exception of one oyster, occurred in the "Upper marine" of Colwell Bay. He also urged their analogy with certain strata immediately beneath the freshwater beds of Hordwell, and compared them with siliceous beds of the Paris basin, now known as the *Grès Moyens*, or Grès de Beauchamp. He considered all the strata exposed between Bembridge Ledge and Ryde as belonging to the

Lower freshwater formation, and laid stress upon this determination, since they had previously been described as part of the Upper series. He observed the oyster-bed and marine marls surmounting the Bembridge limestone, and regarded them as the Upper marine. The coast between Ryde and Gurnet Bay he referred to the Lower freshwater, and was first to notice the remarkable argillaceous beds between Yarmouth and Hempstead, regarding them also as Headon Hill beds, in the lower part of which especially, the Lower freshwater formations may be traced, whilst the upper argillaceous beds are referred to the "Upper marine." He makes the following important statement: "In sinking a well for the use of the barracks near Newport, they are said to have brought up from the depth of 265 feet some specimens of green marl containing fossils exactly resembling some of those which abound at the foot of Hempstead Cliff. I am in possession of one of these specimens, which, if its locality be correctly given, almost proves that the *Lower freshwater formation* exists in some places near Newport about 260 feet below the surface." Although, as will hereafter be shown, this inference respecting the equivalents of these strata is incorrect, the observation is one of consequence, since it would go to show that the elevated ground of Parkhurst was formed of strata belonging to the group to which I propose to apply the name of "Hempstead series." In company with the present Master of Trinity, Professor Sedgwick explored the cliffs of Hordwell, and showed (which all subsequent researches have confirmed) that the beds there belong to the Lower freshwater and Upper marine formations of Mr. Webster. Traces of a small portion of the Upper freshwater Headon beds have since been noticed by Mr. Searles Wood, Dr. Wright, and the Marchioness of Hastings. Professor Sedgwick successfully maintained the true marine origin of the "Upper marine" of Webster against the animadversions of Mr. G. B. Sowerby. In this, however, the difference of opinion, material as it seemed to be, really depended upon the features presented by the same strata observed at different points by different persons. The

so called "Upper marine" of Headon Hill is really little more than a brackish-water formation, whilst the corresponding stratum, a short distance to the north, has evidently been deposited under true saltwater conditions, as seen in Colwell Bay. To the Upper freshwater formation of Webster, Professor Sedgwick referred but a small portion of the island. He remarks that it "may be traced on the north side of the road between the villages of Freshwater and Calbourn; but does not extend very far to the north, nor has its eastern termination been well ascertained." In commenting upon what he did examine of it, he states that "in the higher part of the hill above Tollands Bay we found among the beds of compact limestone the casts of one or two species of land shells, and of a large turbinated shell which we have not previously described. Immediately above the limestone there is a thin bed of clay, containing coaly matter and many shells of the genus *Cyclas* in a state of perfect preservation, and with their valves united. As the same species is very abundant in some parts of the *Upper marine formation*, we imagined during our first visit to the island that we had discovered the trace of a *marine* deposit over the highest *freshwater* beds. The facts stated prove the supposition was devoid of foundation." First impressions are oftentimes truest, and in this instance they came very near the truth.

M. Dumont.

M. Dumont, one of the ablest of European geologists, when on a visit to England in 1851, availed himself of the opportunity to institute a comparison between the older tertiary strata of Belgium and those of England. In his interesting paper on this subject, when describing the Hampshire basin, he notices in some detail the fluvio-marine beds of the Isle of Wight and the Headon Hill sands. The latter he regards as constituting the uppermost of two stages representing his Laeckenien system; the lower division consisting of the Barton clay. He regards the fluvio-marine or lacustrine formation as representing his "Système tongrien." His

descriptions appear to be taken from the Whitecliff Bay and Headon Hill sections combined; and since, like his predecessors, he has fallen into the error of regarding the oyster-bed above the limestone at the former locality as homologous with the "Upper marine" of the latter; he consequently confounds two very distinct stages: and as he evidently regards the upper and lower freshwater and upper marine formations of Webster as entirely constituting the fluvio-marine series of the Isle of Wight, his comparison and identification with the "tongrien" of Belgium cannot be sustained. His remark, that in Whitecliff Bay the lower freshwater is composed of sandy beds with marine shells alternating with lacustrine strata, is incorrect, and results from his mistaking the true "Upper marine" at Whitecliff for a subordinate and intercalated bed in the "Lower freshwater series." He distinctly and accurately, however, notices the truly freshwater beds at the base of the fluvio-marine series at Whitecliff. He divides the whole fluvio-marine into a lower and an upper stage, the former being equivalent to the "Lower freshwater" of Webster, and the latter to the "Upper marine" and "Upper freshwater" taken together. His description of the "upper stage" is drawn mainly from Whitecliff, and consequently is really founded upon higher beds than the great mass of the Upper freshwater of Headon. To the lower or marine part of the upper stage he assigns at Whitecliff a thickness of about two metres, and divides it into, 1. *l'Argile verte à Cyrènes;* 2. *Macigno à Ostracites;* 3. *Marnolite;* and 4. *Sable calcareux à Cyrènes.* The upper or lacustrine division of the second stage at Whitecliff consists, he observes, of a great development of light greenish, grey, subshaly marls, and of red and green marls. In the greenish marl he notices the occurrence of *Cyrena obovata*, and "peut-être la *Cyrena semistriata?*" In the conclusion of his paper he expresses his belief that the fluvio-marine series of the Isle of Wight was formed at the same epoch with the marine marls above the gypsum of Montmartre, and the clays with *Cyrenæ* of Limbourg. "Cette manière de voir serait appuyée par la présence de la *Cytherea incrassata*, du *Cerithium tricinctum*, &c. dans le

dépôt fluvio-marin, qui s'étend entre Alum Bay et Yarmouth, et par celle de la *Cyrena semistriata?* dans celui de Whitecliff Bay, coquilles qui caractérisent, comme on sait, la partie supérieure de notre système tongrien. Si cette détermination se confirmait, l'age du dépôt lacustre supérieur serait aussi définitivement fixé." It is certainly remarkable that M. Dumont, who is inclined to under-estimate the value of the evidence afforded by fossils, should in this instance have been conducted so nearly towards the truth respecting a portion of the Isle of Wight lacustrine strata, by his recognition of the probable affinities of a fossil (that which he terms *Cyrena semistriata?*) not previously distinguished from recorded British species, though assuredly distinct. It is evident that he did not see the same species at Headon; but its absence there did not raise a suspicion in his mind that he was identifying very different strata, and that the beds which he laid most stress upon at Whitecliff, the limestone included, were really superior to the true Headon Hill series. The great differences in mineral character between the two sections may possibly have thrown the truly eminent and accurate geologist of Belgium off his guard, especially when time did not permit of his working out their relations more minutely. In his paper are many very interesting notes on the mineral constitution of these strata, of a kind that are well worthy of imitation by British geologists when they describe sections in detail.

M. Hébert.

At the meeting of the Geological Society of France on the 19th of April 1852, M. Hébert, whose critical investigations into the classification and palæontology of the European tertiaries entitle his opinions to just deference, communicated the results of a comparison, made by him in September 1851, between the lower tertiaries of England and those of the Paris basin. At page 350 of the ninth volume of the Bulletin (second series) of the Society, his views are very briefly embodied in a table, in which the

measures of beds in the Hampshire, London, and Paris basins are contrasted. The views taken by M. Hébert are in many respects singularly opposed to those of Mr. Prestwich, and, indeed, of any other geologist. Thus he places the Bognor beds immediately above the Thanet sands, and as equivalent (with the latter) to sections of the *Calcaire grossier inférieur*. The unfossiliferous London clay of Upnor and Herne Bay he compares with the unfossiliferous sands, No. 28 to No. 7, of Mr. Prestwich's Alum Bay section, and places it as equivalent to the Upper and Middle *Calcaire grossier*. In the marine Barton series, which as a whole he regards as representing the "sables de Beauchamp," he includes, 1st, the bed at the base of the Hordwell series, abounding in *Potamides concavus* (*Cerithium pleurotomoides* of Lamarck); this bed is No. 17 in the section by the Marchioness of Hastings, and 31 in that of Mr. Prestwich. This bed he considers to be the equivalent of "the upper fossiliferous zone of Mortefontaine, Monneville, &c., characterized by an extreme abundance of *Cerithium pleurotomoides*, Lam., and its varieties, *C. concavum* Desh., and *C. rusticum*, Desh." 2d, the white sands of Headon Hill; these he holds to represent "the sands without fossils of Monneville and Mortefontaine;" and, 3d, the Barton clays, No. 29 of Prestwich; these he makes parallel with the "lower fossiliferous zone of Monneville, with *Chama turgidula*, *Voluta digitalina*, &c." I have cited the division of his Barton series in descending order. Above them he places the freshwater formation of Hordwell, which he considers to be the equivalent of that of Montmartre. And, uppermost, in the Hampshire basin he places the marine bed with *Venus incrassata* of Colwell Bay; a stratum regarded by him as newer than all those of Headon Hill, and as representing the base of the sable de Fontainebleau in the Paris basin, the Limburg beds and those of the environs of Mayence.

It would seem that M. Hébert had seen no higher beds than those of Colwell Bay during his visit to the Isle of Wight, and being strongly impressed with the notion that the Upper marine in that locality occupied a far higher

position in the series than it really can claim, was induced to regulate the terms of his comparison accordingly. It will appear in the sequel that the true English equivalents of the grès de Fontainebleau and Limburg beds can be positively shown to be far above the *Venus incrassata* bed of Colwell Bay, and that the latter, so far from being higher in the series than the Headon Hill beds, is in reality present in the midst of them, and occupies the same position as clearly in the section at Whitecliff Bay. Hence it is very evident that M. Hébert's comparative classification cannot stand.

Mr. Prestwich.

[The numerous published memoirs of Mr. Prestwich, based on his own researches, have done so much to elucidate the geological history of this country during early tertiary periods that they require a particular notice in this place: added to this, his perfect acquaintance with the deposits of the Paris basin imparts a special value to all his views respecting the equivalent portions of the lower tertiaries of France, England, and Belgium. These views of Mr. Prestwich have been taken as the basis of my own speculations as to the foreign relations of those higher members of the Isle of Wight series, the description of which forms the main subject of this Memoir.

In 1839,* when, as it appears, Mr. Prestwich first visited the Isle of Wight, the whole of the vertical series of beds in Alum Bay, from the chalk to stratum "B" in Mr. Webster's section,† [the Barton beds], was considered to belong to the age of the "plastic clays" of London and Paris. Stratum "B" was placed on the parallel of the London clay of Sheppey on the side of the Thames basin, and on that of the Barton clay, of the Hampshire deposits; it was referred to the "calcaire grossier" of Paris. The higher series above this was said to be unconformable with the lower, and the hori-

* Journal of Geol. Soc. vol. ii. p. 223–259, 1846.

† In Sir H. Englefield's History of the Isle of Wight. See also Mr. Prestwich's Section in Journal of Geol. Soc. vol. 2, pl. ix.

zontal freshwater group of Headon Hill was supposed to be the representative of the whole of the freshwater deposits of the neighbourhood of Paris. Mr. Prestwich showed that there was a well-marked portion in the Alum Bay section, in which was to be found certain fossils of the London clay and Bognor beds; that it occurred above the first hundred feet from the chalk, and beneath the whole of the variegated sands of that locality. He accordingly suggested that the whole series from stratum "B" to "A" of Webster should be grouped as London clay, and that the term "plastic clay," should be restricted to the hundred feet of mottled clays next above the chalk. He showed that there were no grounds for the supposition of a want of conformity between the series in Alum Bay and that in Headon Hill, and expressed an opinion that no well-marked divisions could be drawn there, as proposed by Webster,* inasmuch as marine shells of the Barton clays re-appear among the overlying freshwater strata in Whitecliff Bay, and that the same freshwater species ranged through nearly the whole thickness of the Headon Hill deposits; the phenomena being such as might be purely local, the result of an accidental irruption of brackish water into a freshwater area.

In this Memoir Mr. Prestwich gave a detailed account both of all the lower tertiary strata of the Isle of Wight and of their included fossils, as then determined. He called attention to the lithological changes which the component beds of the series exhibit even at short distances, and showed that the clays and peculiar shells of Barton occupied in the Isle of Wight a higher place than the Bracklesham group.

With respect to the age of the fluvio-marine series of the Isle of Wight, and their synchronism with the deposits of the Paris basin, Mr. Prestwich states that he felt considerable hesitation in hazarding an opinion; but, guided by the circumstance that all French and English geologists were alike agreed on referring the Barton group to the Calcaire grossier, as also by the consideration of the upward range of the

* Lower freshwater, Upper marine, Upper freshwater.

Barton species, he was disposed to consider the Headon Hill series as the upper portion of the Barton group, and, as such, to refer the whole to the Calcaire grossier.

In the Autumn of 1846 Mr. Prestwich communicated a paper to the Geological Section of the Meeting of the British Association at Southampton, "On the occurrence of Cypris in a part of the Tertiary Strata of the Isle of Wight." *

The place from which these fossil Cypridæ were obtained was the upper part of Hempstead Cliff, near Yarmouth. The author gives a section of the beds, which will be found to agree most accurately with the description contained in the subsequent portion of this Memoir, and notes the genera of the included shells; adding, "We have thus in the lower part of this section a deposit containing essentially freshwater testacea, becoming more mixed, as we ascend, with shells frequenting estuaries."

"It is a singular feature of this group, *which I believe to* "*form the upper beds of the* freshwater formation of the Isle "of Wight, that *a large portion of the species occurring in* "*it are new;* thus the two characteristic fossils are a species "of Potamides and a Melania, neither of which do I find "described. The Cypris also is peculiar to this locality."

From the passages here quoted it will be seen that Mr. Prestwich had the clue to the structure of the upper tertiary series of the Isle of Wight, and that time and opportunity were alone wanting to enable him to work out the details on which the Bembridge and Hempstead groups of the present Memoir will be shown to be clearly separable from the Headon series, with which they had continued to be confounded.

In 1847† Mr. Prestwich showed that the London clay of Sheppey, Highgate, and elsewhere around London, was older than the Bracklesham beds, inasmuch as he detected the fossils of the latter series in the Bagshot sands of Chobham and Woking, and which sands distinctly overlie the London clay. From this he inferred that, instead of the three groups

* Report of Brit. Assoc. for 1846, p. 56.

† Journal of Geol. Soc. vol. iii. p. 353–408.

Cliffs in Alum Bay (looking North).

IX.

of Barton, Bracklesham, and London being equivalents, they were superposed, and he therefore proposed to restrict the term "London clay" to the lowest fossiliferous division of the Alum Bay and Whitecliff Bay sections (the Bognor beds of his first paper). The Bracklesham beds are represented in the same sections by the middle division of the vertical sands, and the Barton clay of the Hampshire coast by the mass of chloritic sands and clays which terminate the vertical series.

Mr. Prestwich was the first to distinguish the changes which the lower marine faunas of the eocene tertiaries of this country present. He suggests what the local conditions were by which such changes were brought about, and, what is of most importance with reference to the higher fluvio-marine series to be described in the following pages, he seems to have ascertained, from an early period of his inquiries, that the marine forms which recur in the fluvio-marine series of Headon and Hordwell were such as belong to the Barton group.]

Lower Tertiary Strata of the Isle of Wight.

[The relation of the "upper fluvio-marine" series of this memoir to the older tertiary formation of the Isle of Wight, as well as the character and dimensions of the several groups, are points which can be well seen and studied either in the coast sections of Alum Bay or Whitecliff Bay. That of Alum Bay is represented by woodcut No. IX.

In this sketch the mass marked (*b*), nearest the white chalk (*a*), and separated from it by a thin band of sand and flints, consists of mottled clays without fossils, which, taken collectively, is usually known as the plastic clay group, and which at this place is about 90 ft. thick.

This group is most probably of freshwater origin, and may be taken to represent the deep-water deposits of that area, of which the marginal line can be traced in part by means of the Reading and Woolwich beds.

This constitutes the lower or earliest fluvio-marine group; and occurs over the French and Belgian lower tertiary areas, with very definite limits.

§ 2. A series of beds composed of dark compact clay, or of dark sand (*c*), is separated from the foregoing by a band of perfectly-formed flint shingle, such as is usually met with in exposed bays. This shingle band is to be seen both in the Alum Bay and Whitecliff Bay sections.

At about twelve paces from the shingle band, and *across* the vertical strata, there is a zone of the *Pholadomya margaritacea* and *Panopæa intermedia*, with their valves joined. A zone of *Ditrupa* occurs about five paces higher, and at twenty-eight paces is a conspicuous band of *Venericardia*. In Whitecliff Bay the parting band of shingle is only two inches thick, and is succeeded by buff-sands (18 in.); and here marine forms appear much earlier, inasmuch as the next bed is full of *Ditrupæ*, at a distance of less than two feet from the "plastic clay."

If the supposition that the mottled clays were deep fresh-water deposits be correct, the marine forms which succeed—*Ditrupa*, *Rostellaria*, *Pectunculus*, would indicate that what took place after the dispersion of the shingle was the substitution of an area of deep sea for what had previously been a deep and extensive lake.

This marine group (*c*) forms the "Bognor and London clay" series of Mr. Prestwich's division of the lower tertiary formation of England, and which in Alum Bay is about 200 ft. thick.

§ 3. That portion of the sketch, woodcut No. IX., which is distinguished by light shading, represents the remarkable succession of strata of various colours, known as the Alum Bay sands, and which are the equivalents of the "Bagshot and Bracklesham" group. In Alum Bay this part of the series is unfossiliferous, so far as animal remains are concerned; but it contains much vegetable matter, and one band in which the remains of leaves have been beautifully preserved.

The whole of this division in Alum Bay, both from the frequent recurrence of bands of lignite, as well as from the

abundance of vegetable matter diffused throughout, has very much the character of a freshwater accumulation. It here attains the vast thickness of 700 ft. The sands which on the Hampshire coast hold a corresponding place in the tertiary series, and which extend from Christchurch westwards, are equally without any remains of marine or freshwater forms. Such, however, is not the case with the equivalent series in Whitecliff Bay. Their thickness is there less; and though they in part exhibit a like lacustrine character, they contain, in one place at least, a group of typical species of the Bracklesham series, such as *Venericardia planicosta* and *Nummulites lævigatus*.

§ 4. The next natural division of the Alum Bay deposits is represented by the mass of dark strata* in woodcut (IX). This succession of beds is marked more or less throughout by an abundance of the remains of marine forms, and which are identical as a group with the well-known fossils from the Hampshire coast at Barton; it constitutes Mr. Prestwich's "Barton group." The limits of this division are well defined in Alum Bay, where it has a thickness of 280 feet. The transition from dark clays to the clean white sands which form the lowest beds of Headon Hill, is here very abrupt; in Whitecliff Bay it is more gradual. At the west end of the Isle of Wight the Headon sands are unfossiliferous, whilst the corresponding beds at Whitecliff contain the casts of bivalve shells and of Barton forms.

It would be difficult to determine from the Alum Bay section whether the Headon sands were to be referred to the marine or to the fluvio-marine series which surmounts them in Whitecliff Bay. They obviously represent the continuation of the Barton group, under the altered conditions of a diminished depth of water. The probability is, that the whole of the tertiary series of the Isle of Wight and Hampshire basin originated under purely local conditions, and that subordinate parts or groups do not admit of any very close comparison or identification, even within the narrow limits of our own area.

* The place is indicated by two birds above the cliff.

The subjoined Table represents the thicknesses, succession, character, and composition, as also the palæontological peculiarities, of the several groups which constitute the lower tertiary series of England where it is most fully and clearly developed. The upper fluvio-marine portion, which will be particularly described in the following pages, extends from the Headon sands to the highest beds on the Table.]

Detailed descriptions of the several members of the lower tertiary series of Alum Bay will be found at pp. 131–136 of Mr. Bristow's Notes.

TABLE of the LOWER TERTIARY (EOCENE) STRATA of the ISLE of WIGHT.

				PALÆONTOLOGICAL CHARACTER.	
2160	Clays and Marls	1	Hempstead Series.	Hyopotamus bovinus.	
		2		Cerithium plicatum and allied species.	
		3		Ostrea callifera.	
		4		Rissoa Chastelii.	
2000				Cyprides. Chara medicaginula. C. Helicteres.	
	Marls.	1	Bembridge Series.	Anoplotherium. Palæotherium.	
		2		Trionyx. Chara tuberculata.	
	Clays and	3		Bulimus ellipticus. Helix globosa, H. occlusa.	
				Achatina costellata.	
				Planorbis discus. Cerithium mutabile.	
1890	Limestone	4		Cyrena pulchra. C. obtusa.	
	Clays, Marls, Sands,	1	Osborne Series.	Chara Lyellii. Melania excavata.	
				Paloplotherium annectens. Dichobune.	
	Sands, Limestone, Conglomerate, Sands.	2		Crocodilus. Lepidosteus.	
1820				Limnæa caudata, fusiformis, and pyramidalis.	
	Clays, F. W. Limestone,	1	Headon Series.	Planorbis euomphalus.	
	Marine Sands,*	2		Cerithium cinctum. C. ventricosum.	
				Neritina concava. Potamomya plana.	
1650	F. W. Limestone.	3		Cyrena cycladiformis. Chara Wrightii.	
	White and Yellow Sands.		Headon Sands.		
1450					
	Brown Clays.		Barton Series.	Venericardia oblonga and V. globosa.	Nummulites variolarius.
				Typhis fistulosus.	
				Serapha convolutus.	Chama squamosa.
1150					
	Brown Clays, Green Sands, Variegated Sands, Pipe-clays, and Lignites.		Bracklesham Series.	Cerithium giganteum.	
				Venericardia planicosta.	
				Turritella sulcifera.	
				Nummulites lævigatus.	
				Cardium porulosum.	
				Crassitella.	
				Fusus longævus.	
1040				Rostellaria rimosa.	
				Trochus agglutinans.	
	Unfossiliferous Sands.		Lower Bagshot Series.		
370					
	Green and Brown Clays, with Septaria Ditrupa Band.		London Clay or Bognor Series.	Nucula amygdaloides.	Marginella.
				Panopœa intermedia.	Rostellaria Sowerbyi.
				Pholadomyæ.	Nautilus Aturi (peculiar to these beds).
				Venericardia Brongniartii.	
				Vermetus Bognoriensis.	Axinus angulatus.
					Cyprina planata.
130			Basement Bed.		Pectunculus brevirostris.
	Mottled Clays.		Plastic Clay.—Unfossiliferous in Isle of Wight.	Melania inquinata.	
				Cerithium variabile.	
				Cyrena cuneiformis and C. tellinella.	
	Sands.		Thanet Sands.	Cyprina Morrisii.	
				Pholadomya Koninckii.	
	Chalk.				

* In marine beds:—Ostrea flabellula; Corbula cuspidata; Nucula Headonensis; Venus incrassata.

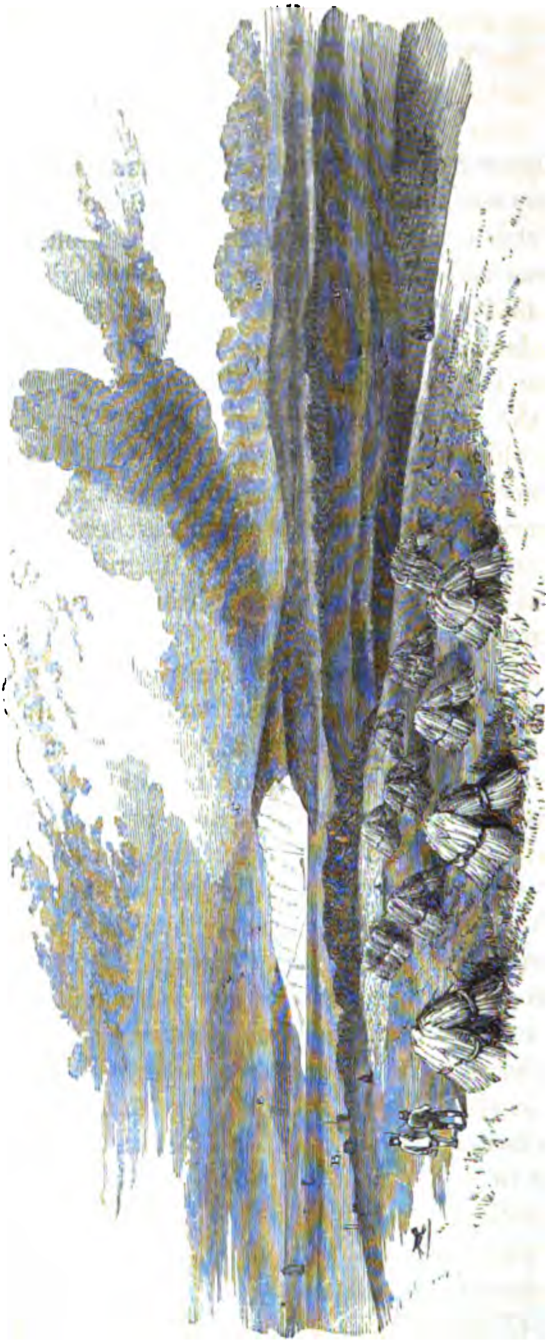
Upper Fluvio-marine Formation of the Isle of Wight.

*a. The Hempstead Series.**

At the distance of a mile and a half eastwards from Yarmouth rises a considerable hill (c), X., p. 38, oblong in shape, sloping towards the south, truncated and exhibiting a series of terraces caused by numerous land slips towards the north. It is known as Hempstead Cliff. The highest portion of its crest is 210 feet above the sea. It is composed entirely of marls and clays, capped on the summit with gravel. The strata are gently recurved and trough-shaped, in consequence of a synclinal axis, the line of which crosses the hill somewhat to the westward of its highest portion. The whole of the beds composing the hill rest conformably on other marls and clays that crop out near its extremities, and towards its southern base, though there the outcrop is entirely concealed by grassy fields. The marls and clays forming its base belong to the Bembridge series, and are identical with those that are seen forming the hill above the limestone at Whitecliff. Here also they rest upon the Bembridge limestone, which indeed is seen at low-water at Hempstead Point, where it marks the summit of an anticlinal curve. The entire area occupied by the Hempstead series, as defined in this paper, is an oblong, not more than two miles in length by rather more than half a mile at its widest diameter. The height of the hill is 210 feet, but the thickness of the Hempstead series is less, although they occupy the entire space between the shore and a considerable length of the crest. This is because the axis of the synclinal

* The upper marls of the Bembridge series have been met with to the south of the high ground forming Parkhurst Forest, from which it may be inferred that the Hempstead series also occurs there. Specimens of the characteristic *Ostrea callifera* have also been found on the surface there; with this exception, Hempstead Cliff is the only locality at which this uppermost member of the lower tertiary series of the Isle of Wight can be seen.—R. G.-A.

X.



View of Hempstead Cliff from the West.

B. Yarmouth. C. Hempstead Cliff. D. Parkhurst. E. Cliffend.

corresponds to a lowering of the crest by denudation. The total thickness of the strata remaining is about 170 feet.

These beds admit of being grouped into several distinct sections. (See Vertical Section, pl. 10.)

1. The *Corbula* beds, strata of marine origin, composing rather more than 20 feet of the highest strata.

2. The *upper freshwater* and *estuary* marls, especially distinguished by the abundance of *Cerithium plicatum*, constituting a thickness of more than 30 feet, and separated by unfossiliferous variegated marls from

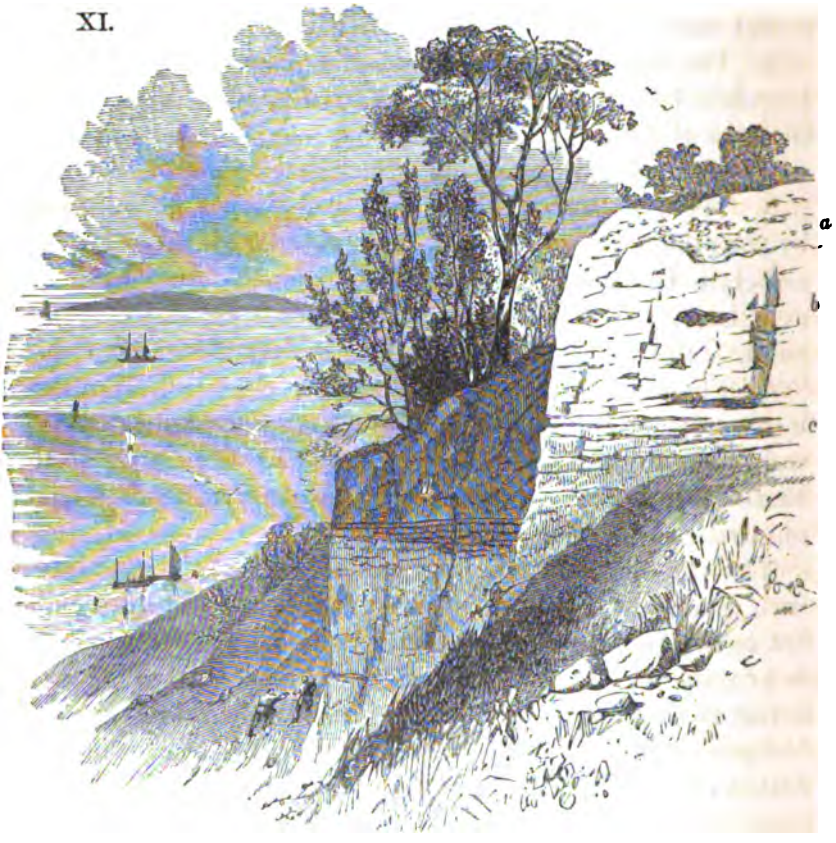
3. The *middle freshwater* and *estuary* marls, distinguished by the abundance of *Melania fasciata*. With these I would associate the unfossiliferous marls immediately below, and as a base, the stratum described hereafter as the White band. The thickness of this division exceeds 50 feet.

4. The *lower freshwater* and *estuary* marls, distinguished by the presence of *Melania muricata* and *Melanopsis carinata*, and excluding the Black band, which I consider to be the basal stratum of the series. This division attains a thickness of more than 70 feet.

The summit, or rather crest, of Hempstead Cliff is capped with flint gravel (*a*), mingled with substratified sand (high level gravel), which rests on different beds at different places, in consequence of the synclinal curve of the strata, whence it results that the highest of the beds beneath the gravel is not necessarily at the highest point of the hill, and is really a little to the eastward of it. (See woodcut XI. p. 40.)

(1.) The highest of the Eocene strata at this place is a bed of sandy grey or bluish clay (*b*), weathering yellow, and containing concretionary portions consisting of fragments of shells often enveloping entire oysters (*Ostrea callifera*) of a different species, form, and much larger size than any of those found in the Headon or Bembridge series. Fragments of other shells occur with them, and in one of the masses I found valves of a *Balanus*. This oyster bed had not been previously noticed, and was discovered by my assistant, Mr. Gibbs, who worked out the details of this portion of the hill with minuteness and accuracy. Occasional *Corbulæ* (*C. Pisum; C. Vectensis*) and *Natica* also occur. This passes

into a greenish clay, with numerous well-preserved *Corbulæ* and occasional *Cerithia* (*C. subcostellatum*), *Natica* and smaller oysters, but these appear to be scarce. The thickness of the preceding beds does not exceed four feet.



Top of Hempstead Cliff.

a. Gravel. *b.* Marine Corbula beds. *c. e.* Lower Cyrena band.
d. Marine Corbula beds. *f.* Shaly clays.

About one foot (but the thickness of this zone varies in different places) of clay charged with large and small *Cyrenæ* (*C. semistriata*) mostly in a fragmentary state, succeeds, forming a whitish band, conspicuous in the cliff, but not seen from far. This is followed again by clay of a bluish hue, forming a bed about eight or ten feet in thickness, containing numerous *Corbulæ* and *Cerithia* as before,

and more or less interrupted by a belt of large hard septaria, pale grey in the fracture, weathering ferruginous, and often studded with finely preserved shells of *Corbulæ* and *Cerithium subcostellatum*, young shells being as common as old ones. *Natica labellata* and *Cyrena semistriata* also occur, but are less frequent; at the base of this clay-bed there is a variable thickness, more shaly, and very full of *Corbulæ* of a different species.

So far the strata, taken in descending order, may be regarded as of marine or saltwater origin, and as constituting the uppermost division of the Hempstead series.

(2.) The bed which succeeds to the *Corbula* clays is a brownish carbonaceous, more or less laminated clay (*e*) containing freshwater shells (*Planorbis* like *lens*, *Limnæa*, *Paludina lenta* and *Unio*), and attaining a thickness of from two to three feet. Half a foot or less of clay filled with *Cyrena semistriata* separates the freshwater bed from a stratum (four feet or less, according to the place, in thickness) of lead coloured clays, with *Cyrena semistriata* and *Cerithium plicatum* and *elegans*, the former species being most abundant, especially in a band of about eight inches width at a foot or so from the bottom of the bed. With the *Cerithia* occur numerous small univalves gathered together in lenticular patches, including *Rissoa Chastelii*, *Hydrobia pupa*, *Melania inflata*, and in thin lilac shale partings of the shelliest portion of the beds *Cytheridea Mülleri*, var. *torosa*, abounds, mingled with small crystals of selenite.

Freshwater clay (a thickness of 2½ feet, but variable) again recurs. It is pale greenish blue, and very tenacious, and in places includes carbonaceous bands. Fish remains occur in it; also many shells, among which is a very large and obtuse *Planorbis*, distinct from *euomphalus*, *discus*, or *rotundatus*, and equalling their greatest dimensions; another species with many whorls in the manner of *P. vortex*; a third related to *P. platystoma*, a largish *Limnæa* (*L. cornea?*), two small short species and numerous examples of a *Paludina* (*P. lenta?*). At the base of this bed is a very black carbonaceous belt, 3 to 6 inches thick, the lower part of which is, in most places, though apparently not constantly, occupied by a band of

Uniones (*U. Austenii*). Dark blue and greenish clays follow for a thickness of nearly 3 feet. Remains of turtle and of fish are found in this stratum, which, though usually filled with fossils, is occasionally almost free from them. A narrow band (1 foot or under) of dark striped sandy clay separates the above from a freshwater bed of 5 or 6 feet in thickness, in which *Limnæa*, *Paludina*, and *Planorbis* occur (the species are the same as before), along with *Cyrena semistriata*. Some 20 feet of unfossiliferous beds, the upper half composed of variegated red and green marls, the lower of grey clays, terminate this portion of the section.

(3.) Fossiliferous beds, rather finely laminated, follow. They consist on their upper portion of alternating blue, green, and ferruginous shaly clays, three feet in thickness, divided by bands of *Unio Gibbsii*, *Paludina lenta*, and small black seeds (*Carpolithes ovulum, var.?*), separated by a belt of almost reniform or potato-shaped concretions of clay ironstone abounding in the same species of shells, from three or more feet similar clays, with carbonaceous zones and pyritiferous belts filled with *Paludina lenta*, seeds, fish scales, *Melania fasciata*, and, in the shales, impressions of plants.

Many of the pyritiferous slabs, studded with beautifully preserved small univalves that are cast about the shore, appear to belong to these beds, having probably been washed out of fallen masses of land slips. The lower portion of these beds becomes obscured by the slips high up in the cliff. Where exposed, they are seen to consist of similar shaly clays, abounding in *Melania fasciata* and seeds, and alternating with *Paludina* clays, beneath which are dark marls, filled with *Cypridæ*, and showing numerous impressions of plants and layers of well preserved *Unio Gibbsii*, a species closely resembling that which I shall have presently to notice when mentioning the lowest beds of the series. These shaly clays appear to rest directly upon mottled marls, often of a yellowish hue, soft, and apt to slip, forming mud-streams in winter, and constituting one of the numerous terraces that naturally mark the divisions of the section on the broken front of the hill. In these marls I could detect no fossils save traces of vegetable

impressions. It is not unlikely, however, that some of these numerous fragments of turtle and similar remains strewing the shore, and derived from mud slips, come out of them. They are fully 35 or 40 feet in thickness.

A marked feature in the series succeeds, in the shape of a more or less consolidated, often highly ferruginous, band of mingled broken and entire shells, forming a white line in the cliff, and a white streak among the fallen and upturned beds on the shore. I have designated this very definite horizon, one exceedingly useful for the guidance of the fossil collector, as the *White band.* A great part of it consists of single valves, sometimes double and always open shells, as frequently only fragments of *Cyrena semistriata.* The best specimens of this bivalve, often of large size, are on the upper surface of the band. It is accompanied by *Paludina lenta, Cerithium Sedgwickii,* apparently peculiar to this zone, *Cerithium inornatum, Rissoa Chastelii* var. *major, Melania fasciata, Dreissena,* and *Panopæa minor,* with shells that I have not found elsewhere in the series, the latter usually double and closed, and small univalves. In one hand-specimen of this band I noticed fragments of *Modiola Prestwichii;* large seed vessels in several. The thickness of this band varies, being sometimes nearly two feet, and in places only an interrupted strip of ironstone with the shells thickly interspersed in the marls above and below.*

(4.) Beneath are about 40 feet of pale blue and yellow shaly marls, with few fossils. Near this uppermost part are *Uniones,* and in these marls, at intervals, are bands of crushed shells, mostly *Cyrenæ* (*C. semistriata*). Ironstone concretions occur, often including small fragments of wood. Fish remains are frequent. These marls rest upon a thickness of 10 or more feet of dark blue shaly clays, with numerous bands of shells, especially *Cyrena semistriata,* which is associated with a very pretty striated *Modiola* (*M. Prestwichii*), and myriads of minute univalves, often filling the cavities of the bivalves, also *Rissoa Chastelii,* var. *major,* and with it,

* See Appendix, p. 111, as to the position of the Panopææ, in the White Band, and the conditions indicated.

a granulated *Cypris*, which occurs still more plentifully in brown shales at the base of these beds. They rest on a series of beds measuring 10 feet or a little more, and consisting in their uppermost parts of compact grey marl, containing bands of *Candona Forbesii* with *Cytheridea Müller*i, *Paludina lenta*, fine and large, *Hydrobia*, also *Typha*-like leaves. These pass into greenish blue clays, with gritty and pyritiferous interrupted belts. In these clays are numerous fossils, those of brackish-water, as *Melania muricata*, var., *Melanopsis carinata*, and *Rissoa Chastelii major* (not found here in abundance, but rather solitary), well preserved; those of freshwater origin mostly in thin layers, such as *Limnæa*, *Planorbis obtusus*, in a rotten condition, even when consolidated by pyrites. Numerous flattened, round, berry-shaped black fruits are found with them, and in pyritous masses portions of the leafy shoots of a yew-like conifer (*Taxites*). *Gyrogonites* also occur here. About 12 feet of laminated and compact pale bluish marls, with seams of *Paludina lenta* and occasional specimens of *Rissoa Chastelii major* intervene between the beds just described and a singularly strongly marked stratum, which I have named the *Black band*, and adopt as the base-bed of the series. It consists of nearly two feet of firm carbonaceous laminated clays, abounding in fossils. These are *Paludina lenta*, very numerous; *Rissoa Chastelii major*, scarce; *Melanopsis carinata*; *Limnæa*; *Planorbis obtusus*, of large size; a peculiar small *Cyclas*, (*C. Bristovii*,) which I have not met with elsewhere; and fish vertebræ. Impressions of the linear leaves of gramineous plants, occasionally large seed vessels, and *Gyrogonites* are found in it, and lumps of lignite. At its base is found a seam of *Unio* (*U. Gibbsii*) containing well preserved specimens.

The Black band rests in perfect conformity on a bed, three feet in thickness, of dark green marls, becoming paler below, and separated by an irregular seam of broken univalves (*Paludina lenta*) from greenish blue pale marly clays, with lenticular seams of crushed *Paludina*. In the dark green marls are scattered fine specimens of *Paludina lenta* and *Melanopsis*, also numerous fossil bones. There are, moreover,

in this bed, curious vertical or slanting tubular concretions, with hollow cavities, as if formed round the roots of plants.

The Black band rises from the shore at an angle of five degrees, nearly under the fir-wood on the eastern side of the synclinal; on the western, its rise and outcrop are concealed by slips, but fallen fragments of it are to be met with on the shore, under the highest part of the crest of the hill. I take it as a base for the Hempstead series for several reasons, and foremost, because it is apparently the first bed that succeeds to those which terminate the Bembridge marls at Whitecliff and elsewhere in the Isle of Wight. This circumstance, combined with those of the beginning of a new series of fossils, of which the *Rissoa Chastelii* is the first conspicuous representative, of the disappearance of others, and the probable indications of a terrestrial surface indicated in some of the features both of this bed itself and the bed below it, may fairly warrant the choice of so well marked an horizon.*

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a'. Fossils of the Hempstead Series.

Shells.

Natica labellata. Lam. Pl. i., f. 6.

Fusus Edwardsii. Morris. Pl. ii., f. 15.

Voluta Rathieri. Hébert. V. Forbesii. Edw. p. 166, pl. xxi., f. 1.
„ n. sp. A fusiform species near to *V. suturalis.*

Cuma Charlesworthii, Edw., rare, and much eroded.

Aporrhais—sp. ?

Murex Forbesii, Morris. Volutions seven, rounded, concentrically banded; bands numerous, irregular, unequal; anterior bands more prominent. A species near to *M. costulata*, from the Calc. Gros. Sup.

Cerithium plicatum. Lam. Forbes. Pl. ii., f. 11.
„ elegans. Desh. Pl. ii., f. 10.
„ subcostellatum. Forbes. Pl. i., f. 7. (C. plicatum, p. 146.)
„ Lamarckii ?
„ mutabile. Lam.
„ pseudo-cinctum, D'Orb.
„ Sedgwickii. Morris. Pl. ii., f. 12.
„ inornatum. Morris. Pl. ii., f. 13.

Melania fasciata. Sow. [M. Nystii. Rissoina Nystii Duchast.]
„ muricata. Wood. Var. costata, Morris (Sow. sp.) Pl. ii., f. 14.
„ turritissima or Forbesii ?
„ inflata. Morris. Pl. ii., f. 8. var. lævis, f. 9.
„ spec. rare, near to *M. semidecussata*, Lam.

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* See notes by Mr. Bristow, p. 106 to 113, and Vertical Section, Pl. 10.

Melanopsis carinata. Sow.
„ subulata. Sow.

Rissoa Chastelii. (*Paludina.* Nyst. Coq. Foss. t. 38, f. 10.) Pl. iv., f. 3.

Paludina lenta. Brander.

Hydrobia? pupa, a small smooth species, with five slightly convex volutions; aperture ovate oblique, slightly oblique below. Very abundant in the middle Hempstead series, with *Cyrena semistriata.*

Nematura parvula, Desh.

Planorbis lens. Sow. Also a large obtuse species.
„ platystoma. Edw.

Limnæa. Two or three species.

Neritina tristis. Forbes. A small globose shell, with the volutions rather angulated; aperture semilunate, inner lip obscurely denticulated, surface smooth without ornamentation.

Neritina, *species.* A small globose species, with zigzag ornamentation; this form is closely allied, if not identical with a species at Headon Hill, associated there with *Hydrobia* (*Bulimus*) *polita,* and *Melania muricata.*

Ostrea callifera. Lamarck. Forbes. Pl. i., f. 5, 5a.
„ A small plicated species near to *O. cyathula,* sometimes attached to *Cerithium plicatum.*
„

Modiola Prestwichii. Morris. Pl. ii., f. 5.

Tellina, sp.

Nucula.

Unio Austenii. Forbes. Pl. ii., f. 7.
„ Gibbsii. Forbes. Pl. ii., f. 6.

Cardium.

Cyclas Bristovii. Forbes. Pl. ii., f. 3.

Cyrena semistriata Desh. Forbes. Pl. ii., f. 1. young shell, f. 2.
„ „ var. Pl. i., f. 3.
„ transversa. Forbes. Pl. iii., f. 6.

Cytherea Lyellii. Forbes. Pl. i., f. 4.

Corbula pisum. Sow. Forbes. Pl. i., f. 1.
„ Vectensis. Forbes. Pl. i., f. 2.

Mya (Panopœa) minor. Forbes. Pl. ii., f. 4.

Entomostraca.

Candona Forbesii, Jones, Pl., vii. f. 22.

Cytheridea Mulleri, Jones. Pl. vii., f. 27, 28.

Cytherideis unicornis. Jones. Pl. vii., f. 24–26.

Cirripeda.

Balanus unguiformis. J. de C. Sow. Darwin, p. 296. Pl. viii., f. 8.

Plants.

Chara medicaginula. Br. Env. de Paris t. ii., f. 7.
„ helicteres. Br. Env. de P. t. ii., f. 8. } (Forbes.)
„ tuberculata. Lyell and var. *Morrisii*. See Appendix.

Taxites (or Glyptostrobites) Parisiensis. Brong.

Folliculites thalictroides, *var.* Brong. sp. This form appears to be the same as that found in the Bembridge and Headon series.

Reptiles.

Trionyx incrassatus. Owen.

Mammals.

Hyopotamus bovinus. Owen. Geol. Journ. v. 4, p. 104.
„ Vectianus. Owen. Geol. Journ. v. 4, p. 103.

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a″. Foreign Equivalents of the Hempstead Series.

[As the subdivisions of the French tertiary series (those now proposed either by M. D'Archiac or M. C. D'Orbigny) may not be generally understood by English geologists, and as they will be frequently referred to in the following pages, I have thought it best to place that of M. C. D'Orbigny at the head of the present section; and to this I have added on one side a column, by means of which it can be compared with the general table of foreign equivalents (p. 101), on the other a list of the principal fossil species in each group.

Gr. iii.	1. 2.	xi. Travertin Supérieur. Calcaire d'eau douce. Sometimes replaced by the "Argile et meulière."			Planorbis Prevostinus. P. rotundatus. P. cornu. Limnæa cornea. L. fabula. Bulimus pygmæus. Pupa Defrancii, Helix Lemani. H. Desmarestina.
Gr. iv.	1.		a. Sands not micaceous; and with marine shells.	Hempstead Series.	Corbula rugosa. Cytherea nitidula. C levigata. C. elegans. Donax retusa. Pectunculus pulvinatus. Melania costellata. Cerith. cristatum. C. cinctum. C. lamellosum.
	2.	x. Sables et Grès de Fontainebleau.			
	3.	Sables et grès marin supérieur.	b. Micaceous sands.		C. mutabile. Fusus longævus. Oliva.
Gr. v.	1.		a. Upper (marine).	Bembridge Series.	Ostrea callifera. O. longirostris. O. cochlearia. O. cyathula. O. spatulata. O. linguata. Cytherea elegans. C. semisulcata. Cardium obliquum. Nucula margaritacea. Natica patula. Cerithium plicatum. C. cinctum.
	2.	ix. Marnes supérieurs au Gypse	b. Middle. (Travertin moyen.)		Limnæa longiscata.
	3.		c. Lower (marnes fluviatiles.)		
	4.	viii. Terrain Gy x.			
	5.	vii. Travertin inférieur.			Limnæa longiscata. L. rotundata. Planorbis lens.
		vi. Grès de Beauchamp.			Cyclostoma mumia.

The list of fossil shells which characterises the uppermost of the foregoing groups will not warrant the supposition that there is any portion of the Isle of Wight series which can be placed on that parallel. The abrupt termination of the Hempstead Cliff section, owing to the denudation the dis-

trict has experienced, indicates that our series is incomplete, whilst what remains shows also that it is only the commencement of a more perfect marine group of strata. The character of some of the denuded beds may be some day ascertained from an examination of the fragments of yellow marine tertiary sandstone, which are occasionally met with in the overlying gravel of Hempstead Hill, and which are not referable to any lower portions of the series.

The highest fossiliferous bed in Hempstead Cliff is that with the *Ostrea callifera*, and it is also that of the first appearance of this form within our area. It will be seen by reference to the foregoing table of the sequence of the French series, that marine beds form the upper portion of M. D'Archiac's 5th group, and that the Fontainebleau group (4th), as a whole, is also marine; the divisional line is therefore somewhat arbitrary. With reference to former physical conditions, we may safely merge these two divisions into one, and consider it as representing the latest occupation of the Paris basin by the waters of the eocene sea. All the French observers agree in representing the position of the *Ostrea callifera* to be a definite one in their series—as commencing in the upper part of Group V., and ranging upwards into the Fontainebleau series. The only difference of opinion seems to be as to whether certain beds referred to the top of Group V. ought not with greater propriety to be considered as belonging to the base of the higher one. *Cerithium plicatum*, with a like range, and equally abundant in the upper Hempstead beds as in those of the Paris basin, is another form which may serve to indicate the equivalent parts of the formation.

The contents of the beds which underlie the true marine ones at Hempstead Cliff (Corbula beds) are not sufficiently characteristic to enable us to put them in close comparison with any part of the French upper series, but if we take the uppermost marine groups of the two countries to have a general correspondence in time, the process of change would seem to have been by a longer continuance of brackish water conditions on this side than on the other, and in this way the Travertin moyen may become the representative of the middle division of the Hempstead series.

So likewise the lists of species indicate the middle Limburg beds* of Sir Charles Lyell's arrangement of the Belgian tertiary groups as the nearest equivalents of the marine series of Hempstead.]

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b. Bembridge Series.

Of the fluvio-marine eocene strata of the Isle of Wight, the Bembridge series is by far the most constant in lithological characters, and the changes exhibited by the component strata throughout their range are for the most part slight and unimportant. They are consequently everywhere easily recognizable by mineral composition, and, as might be expected, their most characteristic fossil contents are, in the main, very uniformly distributed. The lower portion of the series is most calcareous, and everywhere in the island exhibits more or less compact limestones, occasionally separated by shales, and accompanied by marly beds. The upper and larger division consists of alternations of marls and laminated clays, with a few sandy bands towards the base, and an occasional hard band higher up. Taking the whole series, and subdividing according to the distribution of its fossil contents, I distinguish four subdivisions, of which the three upper belong to the most argillaceous, and the lower to the calcareous portion. I propose to designate them successively in descending order:

1. Upper Bembridge marl.
2. Lower Bembridge marl.
3. Bembridge oyster bed.
4. Bembridge limestone.

By far the larger portion of the tertiary surface of the Isle of Wight is occupied by strata, which, previous to these researches, held no distinctive place in British geology, and were, indeed, supposed erroneously to be continuous and contemporaneous with the characteristic beds of Headon Hill, *i.e.* with the Headon series, although really much

* Lyell, Quart. Journ. Geol. Soc., vol. viii., p. 312, et seq.

higher in position, and for the most part wholly absent from the Headon section. Locally and economically, they are of much greater consequence than any of the other tertiaries, since the agriculture of the northern division of the island is chiefly dependent upon them, and much of the stone used for building is derived from their harder beds. In a scientific point of view they possess very high interest, since, in turn, we have the representatives of extensive continental formations, and through them we are enabled to throw considerable light on the classification and relations of much discussed foreign tertiary strata. To the naturalist they are peculiarly attractive, since through them we acquire considerable information respecting the terrestrial fauna of our area during the later portion of the eocene epoch, and obtain numerous forms of organic remains peculiar to these beds.

The first of these subdivisions consists of a considerable thickness of marls and laminated grey clays, the latter prevailing westwards. This portion is often separated from the next by a hard though usually thin calcareous band. Palæontologically the *Upper Bembridge marls* may be characterized by the great abundance of a partly subulate spiral univalve, named by me *Melania turritissima*. The best localities for examining them are in Whitecliff Bay, on the shore at Hempstead, and at Thorness.

In the second group, unfossiliferous mottled clays alternate with fossiliferous laminated clays and marls. Fragments of *Trionyx* are frequent in them, and a large form of *Cerithium mutabile* with some remarkable *Cyrenæ*, especially *Cyrena pulchra*, are highly distinctive of these beds. They may be examined with facility in beautifully clear sections in the two first localities just mentioned for the upper beds, and below St. Helen's by Brading Harbour.

The third group is of least extent of all four, forming a narrow but constant band between the marls and the limestones. Its importance depends on the evident influx of salt water during its deposition, as marked by the abundance of oysters, accompanied by marine shells of various genera. Eastwards arenaceous deposits prevailed during its formation; westwards the peculiar features of this group become ob-

secured. The best localities for examining this section are Whitecliff Bay (where these beds were long mistaken for the "upper marine," or Middle Headon strata), and below St. Helen's by the entrance of Brading Harbour.

The fourth subdivision includes the limestones long known as those of Binsted, Cowes, Gurnet Bay, Calbourn, Dodpits, and Sconce; but hitherto always, and in some measure unaccountably, confounded with the limestones of the Headon series. This mistake has arisen chiefly from the misinterpretation of the Whitecliff section, where the oyster beds just referred to having been confounded with the "upper marine," the strong limestone of Bembridge that underlaid them was consequently identified with the lower freshwater limestones of Headon Hill, a serious error that has hitherto vitiated all comparisons of the British with continental eocene beds. As it is most convenient to describe the Bembridge series in ascending order, I shall first give an account of these *Bembridge limestones.*

Bembridge Limestone (4) *at Whitecliff Bay and at Bembridge Ledge.**

The limestone in Whitecliff Bay forms a conspicuous and well developed member of the eocene strata exposed in that locality. It is the only limestone of any importance displayed in the section. In the cliff it rises from the shore with a rapid and sudden curve; its uppermost portion inclining at a high angle. Between Foreland Point and the margin of the bay it forms in great part the floor of the shore, with a hollow and slightly basin-shaped curve, dipping inwards and landwards on the east and south-east. The extension of the broken margin of this shallow trough constitutes the reef of rocks known as Bembridge Ledge, and quarried at low water for a building stone. Rolled fragments of the limestone strew the bay, and mingle with the flint gravel of the drift to form the shingle. At a distance it is conspicuous among the neighbouring strata, owing to its general creamy-white hue and the angular fracture of its beds. When closely

* See Vertical Section, Plate 10.

inspected it is found to consist of a number of distinct strata varying somewhat in thickness in different parts of the bay, and yielding different measurements to observers in different years, owing to the occasional swelling out of the individual beds. Their mutual relations and distinctions seem, however, to be very constant in this locality. The best point for the examination of them is at the place where the great curve of the limestones first reaches the shore, and where they are exhibited in their entirety with perfect clearness. Here this division of the Bembridge series is composed of the following elements, enumerated in ascending order and (in 1852) thickness:

1. Yellowish compact limestone, weathering rather darker, exhibiting in the fracture minute confervoid ramifying cavities. This bed is very full of casts of *Limnæa longiscata* and nucules of *Chara tuberculata* are scattered abundantly through its substance. A small *Paludina*, a *Hydrobia*, and a *Planorbis* (*oligyratus*) occur occasionally. The average thickness is 3 ft. 6 in.

2. Greenish grey marly clay, with an irregular and crumbling fracture; it contains crushed shells of *Limnæa longiscata* and *Planorbides*. 4 ft. 6 in.

3. Compact creamy yellow limestone, abounding in casts of *Limnæa longiscata*, of which parts of it seem almost entirely made up; also *Planorbis oligyratus?* The nucules of *Chara tuberculata* occur in this bed, but not so plentifully as in No. 1. The uppermost portion of it is conglomeratic. 5 ft. 6 in. This is the bed most sought after here for building, yielding blocks of considerable dimensions.

4. Pale, often white marly limestone, in some places becoming very compact; remarkable for abounding in myriads of a small, rather globose *Paludina* (*P. globuloides*); containing also *Limnæa longiscata*, a small *Hydrobia*, and, more rarely, *Cyclostoma mumia*. When this bed is much exposed superficially it forms a flat white platform, with an undulated and much cracked surface, the cracks extending throughout its thickness. In its uppermost part is a paleish carbonaceous strip abounding in comminuted shells of *Cyrenæ*. The *Chara tuberculata* occurs in it. 3 ft.

5. Greenish white limestone, very concretionary and fossiliferous. Small patches of a white mineral are highly distinctive of this band. *Limnæa longiscata* is the most abundant fossil. Of other shells I find in this locality *Planorbis discus*, *P. rotundatus*, *P. Sowerbii*, and *P. obtusus*, a new *Paludina* (identical with that in No. 1), *Helix occlusa*, *H. labyrinthica*, and two other species. The uppermost six inches are very conglomeratic. This cap weathers pebbly, and contains freshwater shells; when removed by the action of the waters the stone below weathers with a rough and pinnacled surface, speckled by the white mineral and very shelly. The substance of the bed is much less shelly below. The thickness at the margin of the bay is 4 ft. 3 in.

6. Crumbly white marl, with small globular concretions. *Chara tuberculata* has its uppermost limit apparently in this bed. *Planorbis obtusus* is common in it, but, like all other shells in the Bembridge limestones, is almost always in the condition of a cast. 2 ft. 7 in.*

Total thickness at Whitecliff Bay, as exposed in November 1853, 24 ft. 3 in. When measured near the same spot by Captain Ibbetson and myself in 1854, we made it 27 ft. Mr. Prestwich, in his section, states the thickness as 26 ft. These discrepancies arise from the varying thickness of the beds exposed as seen in different years, the waves of every winter making inroads on the land.

Its western and inland outcrop on the other side of the peninsula of Bembridge is very inconspicuous, but may be traced on the shore below Woolverton farm.

Near Foreland Point the remarkable palm leaf (*Palmacites*) figured by Dr. Mantell in the "Geological Excursions round the Isle of Wight," 1854, p. 311, was found in one of the beds of the Bembridge limestone.

Bembridge Limestone at entrance of Brading Harbour below St. Helen's.

Although the distance of this section from the last described is very little above two miles, there is considerable difference in the thickness and arrangement of this set of beds.

* See Notes p. 113, and Section No. 9.

There are three distinct and well separated bands of limestone at St. Helen's, the lowest resting on the greenish carbonaceous clay which terminates the Osborne series here. I shall describe these and the intermediate strata in ascending order.

1. The lowest band is a yellow limestone abounding in small concretions, and containing few fossils. *Limnæa longiscata* and a *Paludina*, are present in it as casts. 1 ft. 6 in.

2. A bed of greenish marly sand succeeds, with few traces of fossils. I found traces of casts which appeared to belong to *Melania excavata* in this bed. If so they might have been derived from the beds below. 5 ft.

3. The second limestone band is a rather soft and greenish-white stone, exhibiting when broken small cavities, being the hollows of empty shells, often containing a bituminous substance, probably derived from animal matter. The prevailing and very abundant shell is *Planorbis oligyratus*, with the test preserved. *Limnæa longiscata* occurs, but not plentifully. *Planorbis discus* and a *Paludina* also occur, with *Chara tuberculata*, and another species is present in considerable plenty. 1 ft. 8 in.

4. Carbonaceous and shaly clays becoming calcareous and marly downwards, and containing lines of broken *Cyrenæ ;* 2 ft. 5 in.

5. Third and uppermost band of limestone of inconsiderable thickness, yet very varying characters in its different portions. Its lower third weathers white, and is compact. It abounds in *Paludina globuloides*, and at its base is crowded with numbers of *Chara tuberculata*. The middle portion is of more crumbly texture and darker colour, weathering of a pale brown. It is well filled with casts of *Limnæa longiscata* mixed with *Cyclostoma mumia* and *Planorbis obtusus*. *Bulimus ellipticus* and a *Paludina* occur here in this horizon. The upper third may be divided into a conglomeratic and concretionary uppermost portion, and a lower division, in which occur lenticular silicious concretions and bands of chert. On the surface of the concretionary cap single valves of *Cyrena semistriata*

and *Ostrea*, with occasional casts of a large *Cerithium*, abound in several places. 3 ft. 4 in.*

Bembridge Limestone at West Cowes, Gurnet Bay, and Hempstead Ledge.

In all these localities, and wherever the limestone appears between Cowes and Yarmouth, it presents very uniform characters, and is highly fossiliferous, abounding especially in *Limnæa longiscata*, as usual in the condition of casts. *Planorbis* is rare, and *Paludina orbicularis* occurs occasionally. The white compact sand containing *Paludina globuloides* is well marked, and from its superior toughness the pebbles of it are easily recognized among the shingle on the beaches near Cowes. *Gyrogonites* are abundant and well preserved. The limestone rises immediately along the quays at Cowes, with a rapid ascent, and forms the foundation of the houses built by Sir Charles Fellows on the Parade Its general curve determines the form of the slope upon which Cowes is built, although on the surface it is not seen, being concealed by the superincumbent marls, and eventually by the gravel. It makes a conspicuous curve in the cliffs on each side of Gurnet Bay. In those localities it does not appear usually to be thicker than from 15 to 16 feet, and the beds are calcareous throughout.

Bembridge Limestone at Sconce and Cliffend.

For years this locality has yielded many of the most interesting fossil shells found in the Isle of Wight tertiaries, especially species of terrestrial origin. Not a few of the rarer and more curious pulmoniferous molluscs, so well figured and described in Mr. Frederick Edwards's excellent monograph, were discovered at Sconce. Had the true position of this limestone been noted on the spot, its superposition to the Headon beds, and the peculiarity of its fossil contents, —the homology of the Sconce rock with that of the Dodpits and Binsted could not have been overlooked, and the mistakes about the place of the two latter, viz., their assign-

* See Vertical Section, Plate 10, and Section p. 122.

ment to the "lower freshwater," *i. e.* Lower Headons, would not have been committed. I was greatly surprised on my first visit to Sconce to perceive that no attention had been paid, *geologically*, to one of the most interesting localities in the Isle of Wight, one from which so many rarities had been procured which had never been seen at Headon, and the absence of which from the well explored portions of the Headon section ought to have suggested the desirability of a minute determination of the stratum in which they occurred.

The Bembridge limestone at Sconce, a mass of limestone and marls, is from 16 to 20 feet in thickness. It rises with the slope of the hill opposite Yarmouth, and forms the partly mural crest cropping out at Cliff End. Owing to a slight dislocation it dips S.E. at an angle of 5 degrees. The entire thickness is composed of calcareous beds passing into each other, very concretionary, variable within short distances, and of a highly travertinous character. Indeed, very much of the limestone in this locality is a true travertine, or calc-tuff. Much of it has a peculiar brecciated appearance not presented by the Headon limestones, and the porosity dependent on the presence of irregular confervoid tubular cavities, so characteristic of the Bembridge limestone in all its localities, and so strikingly comparable with a like appearance exhibited by the travertines of the Paris basin, is very manifest in the rock at Sconce. The cause of this structure first noticed by Von Buch, and afterwards laid stress upon by Cuvier and Alex. Brongniart, has been frequently discussed by French geologists, who are inclined to refer it to the effect of the disengagement of gaseous vapours. I am inclined to refer some of these appearances to the ancient and now obliterated presence of vegetable bodies, such as chara stems and algæ. The distinctive palæontological feature of the Sconce locality for this limestone is the remarkable abundance of land shells in it. These occur for the most part in the upper half of the beds, freshwater shells being more frequent in the lower, but much of the strata here seems entirely unfossiliferous. In some places the mass of land shells seems to lie in irregular tufaceous bands between harder strata, the latter abounding in *Limnæa longiscata*, *Planorbis discus*, *P. obtusus*, and

P. oligyratus, mostly in the condition of casts, but nevertheless exceedingly well preserved and easily extracted. Great blocks of grey sandy limestone lie along the shore, fallen from the hill crest, full of *Planorbides* and *Limnææ*, mingled with occasional *Helices* (*H. occlusa*, *H. D'Urbani*, and *H. Vectensis* being most common), and the fine *Paludina orbicularis*. These blocks are broken up by the native collectors, who seek especially for the last-named shell, and for *Bulimus ellipticus*, *Achatina costellata*, and *Helix globosa*, all species of great size and beauty, that find a ready sale among visitors. In a thin white band beneath a belt of *Limnæa longiscata* I find here the little *Paludina globuloides* occupy the same horizon as at Bembridge and Cowes, and remarkable for its constancy of place. The most concretionary and brecciated portion of these beds consists of a white band from 6 inches to a foot thick not far from the uppermost layer, and evidently comparable with the cap of the limestone at Bembridge. Just below the top, every here and there, a hard band of silex, often nodular, reminds us of the cherty layers near the summit of this limestone at St. Helen's. Four or five inches of soft calcareous marls, with small limestone pebbles (or possibly concretions), form the very uppermost portion. In the line of the tufaceous concretionary portion is a curious layer or old surface, in which lie the remarkable bodies regarded by Mr. Edwards as turtle's eggs. On these I shall make some remarks hereafter.

Besides the fossils I have mentioned *Helix omphalus* and *H. tropifera*, *Pupa perdentata* and *P. oryza*, *Clausilia striatula*, *Cyclotus cinctus*, and *Succinea Edwardsii*, have all been collected by myself and Mr. Gibbs in this prolific locality. The *Clausilia* and *Cyclotus* are by no means uncommon. Although diligently searching for many days we met with no remains of vertebrata.

*Bembridge Limestone at Headon Hill.**

This important member of the Isle of Wight tertiaries plays but an inconspicuous part in the Headon section.

* See Vertical Section, Plate 10.

Among the grassy slopes beneath the gravels that crown the summit of the hill white and yellowish sandy marls appear here and there in the broken ground, and occasionally are varied by containing hard white compact limestone nodules, breaking with a sharp-edged and splintering fracture. A little to the north of the summit, these beds, dipping northwards, become rather more developed, and exhibit more marked features, as concretionary and travertinous limestones. In no one place are they, however, fairly exposed. The turtle-egg bodies occur among them in regular lines. The fossils found in the concretions are almost invariably terrestrial, and consist of *Helix D'Urbani*, *H. omphalus*, *H. occlusa*, *H. Headonensis?* *Bulimus ellipticus*, *Pupa perdentata*, and *Cyclotus cinctus*. The thickness of these beds at this locality, although they make no prominent feature, can scarcely be less than 15 ft.*

Bembridge Marls at Whitecliff Bay and Foreland Point.†

It is most convenient to describe the three upper subdivisions, and, in point of bulk and surface, principal portion of the Bembridge series together, since they pass in many places gradually into each other.

At Whitecliff Point the band of white compact marl that forms the uppermost bed of the limestone group is surmounted by softer greenish marls, with lines of white nodules in the lower part, to a thickness of nearly 3 feet.

Whitish sands, with lines of *Cyrena semistriata* mingled with occasional specimens of *Cerithium*, interstratified with fine stripes of clay, and occasional pebbles succeed, to the extent of 2 feet.

Then come green sandy beds, coloured by silicate of iron, and containing oysters in abundance (*Ostrea Vectensis*), the uppermost portion of finer sand; 2 feet.

Dark shaly clays succeed, with *Cyrena semistriata*, or thin lower portion, 2½ feet; capped by a remarkable and very constant band of hard unfossiliferous bluish septarian stone.

This stone-band strikingly resembles in mineral character

* For further details see Notes by Mr. Bristow, p. 113 to 120.
† See Vertical Section, Plate 10.

the harder insect-bearing limestones of the Purbeck beds. It is thickest (about 1 foot) and finest about half way between Whitecliff Point and the Foreland, where its upper surface forms part of the floor of the shore. Everywhere it preserves the same peculiar mineral character. Near the same place the finest display of the oyster bed, the surface of which forms the floor of the shore, is seen. There it is underlaid by a pale concretionary blue marl, containing occasional pebbles, and abounding in casts of shells, especially of *Cerithium* (probably *C. mutabile*), occasionally mingled with casts of freshwater shells (*Limnæa longiscata, Planorbis discus* and *obtusus*), *Cyrenæ* of more species than one, a small angulated *Corbula*, a ribbed *Murex* (*Forbesii, ?*) a curious pupa-like *Bulimus ?*, occasional *Mytili*, *Hydrobiæ*, a Tellinoid bivalve, occasional examples of *Melania muricata*, and traces of fish. Between this blue marl and the oyster band is a thin sandy bed, filled with comminuted shells, and on this rest numerous individuals of *Cytherea incrassata*, with their valves closed, but the shells are in so exceedingly decayed a condition that, after many trials, I was unable to remove any entire. The internal casts, however, are very fine and transportable. Then come the oysters, mostly, but not all, single valves, and dead shells, here and there mingled with good double specimens. They are thinly distributed, but occasionally occur in clusters of considerable number, bristling the surface of the shore. Individuals vary much in shape in the same cluster. With them are *Mytili* (*M. affinis*), *Nucula similis*, a *Solecurtus*-like bivalve, and I have once met with a *Natica*. The *Mytili* and *Nuculæ* retain their shells perfectly. Occasional pebbles are mingled with the oysters.

At the edge of the cliff, half way between Whitecliff Point and Foreland Point, just beyond the place where the oyster bed is best displayed on the shore, the beds immediately surmounting the septarian stone band are minutely exhibited. Dark blue clays, scattered shells (double) of *Cyrena obtusa* and *C. obovata* first come on. Then darker and more friable shaly clays, including a strongly marked band of *Cyrenæ*, the species being *C. pulchra, obtusa*, and

obovata, mingled with occasional large examples of *Cerithium mutabile*, of which now and then a specimen may be found with a *Balanus* attached. Then come pale laminated clays, containing the same shells. These are succeeded by greenish marls, crowded with little knots of *Serpulæ*. Clays and shaly strata follow, including a thick band composed almost entirely of *Melania costata*, associated with *Cyrena semistriata*, which latter shell forms also a band of its own. The specimens of all these shells are beautifully preserved. In the clays and mottled marls that follow, shells are scarce or wanting, but fragments of turtle occur, and I had the good fortune to find in situ the greater part of the carapace of a *Trionyx incrassatus*.

To resume the section at Whitecliff Point. The band of septarian stone is there surmounted by laminated clays, in which, at the height of about a foot, there appears a marked zone of bivalves, consisting of *Cyrena semistriata*, *C. pulchra*, *C. obovata*, and *C. obtusa*, associated with *Cerithium mutabile*, and followed by *Melania costata*. At about a thick ness of 4 feet above the stone-band these clays contain a zone of *Serpulæ;* they then change, and present whitish streaks. In this portion are shells of *Melanopsis fusiformis* and *Paludina lenta*. About 24 feet of variegated red and green marls follow, without shells, or containing slight traces of *Cyrena;* fragments of turtle occur in these marls. Then come 3 feet of pale blue laminated sandy clays, with traces of fish, and containing a few pebbles of limestone and flint. Five feet of red marls without fossils succeed.

At this point there is a marked change, indicated by a band of stone, sometimes siliceous, sometimes calcareous, and varying in thickness, its maximum being four feet. It is often very concretionary, and then contains very few fossils; and here and there it passes into calcareous marls. Where most fossiliferous I have found in it *Bulimus ellipticus*, *Achatina costellata* (both scarce); *Limnæa longiscata*, an elongated variety, not abundant; a *Unio*, *Cyrena transversa*, *Paludina lenta*, *Melania costata*, and nucules of *Chara*. I regard this band of stone as peculiarly interesting, on account of its possible analogies with the "Travertin moyen" of the Paris

basin. It constitutes the division between the upper and lower Bembridge marls.

Eight feet of pale blueish sands and sandy clay succeed. These contain zones of *Melania turritissima*, *Melanopsis fusiformis*, and *Paludina lenta*, also remains of fish and seeds.

Then come 10 feet of lead-coloured clays, laminated above, paler below, and including numerous bands of *Paludina lenta*, and a more elongated species, *Melanopsis*, *Melania turritissima*, occasional *Cyrenæ*, and remains of fish.

Three feet of pale shaly clays, the lower part with a band of septarian concretions, containing *Paludina lenta* and other shells.

These are succeeded by 8 feet of variegated yellow and brown clays, sandy in places, and containing lines of nodular concretions, but no fossils. These terminate the summit of the cliff, below the superficial gravel.

Bembridge Marls at St. Helen's.

At the entrance of Brading Harbour, a little seawards of the old church tower that stands on the sea shore, there is a very good section of the marls surmounting the limestone. The greater portion is exactly similar to the corresponding part of the Whitecliff Bay section; but there are some slight though interesting differences in the region of the oyster beds, worthy of detailed notice.

The top of the Bembridge limestone in this locality, as mentioned in the account of that rock, presents a surface somewhat irregular, and including oysters, *Cyrenæ*, and casts of *Cerithium*. This is immediately succeeded by half a foot of greenish clay containing oysters. Then comes half a foot of brown clay charged with *Cyrenæ;* a coarse greenish clay, 1 foot thick, succeeds, having a crumbly and angular fracture, and including *Melanopsis fusiformis*, *Cyrenæ*, and a small *Melania*. The dark shaly clay, 1 foot thick, above this contains *Cyrenæ*, and is surmounted by some four or five inches of pale lilac, compact, septarian stone, weathering white. Nearly two feet of dark laminated clays and marls succeed, containing in their upper part a band

filled with *Cyrena semistriata*, accompanied by *Cyrena obovata* and *Cerithium mutabile*. Then come greenish and variegated marls.

A peculiarity in this section is the presence in the brown clay above the oyster clay of some shells of marine origin that I have not noticed elsewhere; these are a pretty little *Arca* (*A. Websteri*), and a *Modiola*.

Bembridge Marls, on the Coast between Cowes and Newtown.

Wherever the limestone appears on this coast, or disappears in consequence of diving beneath the sea level, the marls above it are well preserved, not always, however, of their entire thickness. At Gurnet Bay, whitish marls, separated by a carbonaceous band, immediately surmount the limestone, and then succeeds about a foot thick of blue clay and shelly stone full of *Cyrenæ*. This is surmounted by nearly three feet of dark shaly clays containing oysters, *Cyrena pulchra* and *obovata*, and *Cerithium mutabile*, a shell here much more plentiful than I have observed it elsewhere. A well marked band of unfossiliferous pale blue septarian stone succeeds; then come some 10 feet of shales and clays, with *Cyrena obtusa* and *obovata*, *Melania muricata*, and the *Cerithium*, which fossils re-occur in clays and shales occasionally forming compact bands to the summit of the cliff. At the point where this section was noted the upper beds of the Bembridge limestone only are above the shore.

More to the west, at Thorness Point, there is a good section of the middle beds of the marls, exhibiting the following succession in descending order:—

a. Green clays, with plentiful specimens of *Melanopsis carinata*, and, less abundantly, *Paludina lenta*, *Melania turritissima*, and *Cyrena obovata*; 6 ft.

b. Band of comminuted *Melaniæ*; 2 in.

c. Dark green shaly marls, with ferruginous concretions, and numerous specimens of *Melania muricata* and *Melanopsis carinata*, a belt of which shell forms the base of this bed; 2 ft. 2 in.

d. Green marls, with *Paludina lenta*; 2 ft. 3 in.

e. Pale yellow stony band, composed of comminuted shells, and becoming a limestone. Broken *Cyrenæ* and *Melania muricata* form the mass of it. 1 ft. 2 in.

f. Green clays, with lines of broken *Melania muricata;* 2½ in.

g. Band of comminuted *Melania muricata;* 2 in.

h. Green marly stone, with a well preserved band of *Melania muricata;* 4½ in.

i. Band of comminuted *Cyrenæ;* 4½ in.

j. Grey septarian stone band, capped by a thin layer of greenish stone, with fucoidal markings; 5 in.

k. Greenish marls, with bands of finely preserved *Cyrena obovata,* very abundant, patches of *Melania muricata,* and scattered shells of *Paludina lenta;* 2 ft. 6 in.

l. Band of septarian stone; 2 in.

m. Green clays, full of *Melania muricata,* constituting the last bed exposed upon the shore.

Bembridge Marls between Newtown River and Yarmouth.

At the western arm of the shallow bay or curve where Newtown river flows into the sea, some projecting rocks are marked upon the map called Hempstead Ledge. At low water, spring tides, this ledge is exposed, and is seen to consist of a creamy limestone, which upon examination proves to contain the association of fossils characteristic of the Bembridge limestone, especially masses of *Limnæa longiscata,* underlaid by a belt of *Paludina globuloides.* It is in fact near the summit of a curve of the Bembridge limestone, the last visible anticlinal as we proceed westwards along the coast, and is the western base of the Bembridge marls that exhibit a synclinal curve below Thorness Wood. Westwards along the shore at low-water mark, the marls that rest upon the limestone are exposed, regularly dipping at a low angle, about 5° W., and showing the outcropping edges of the successive beds without the intervention of a single break, not even an inch of the section being obscured. This section is of great consequence, since it conducts us in the most perfect manner possible from the definite horizon of the Bembridge limestone into the strata belonging to the

Hempstead series, and completes the succession of Eocene strata, which in Colwell Bay we see as clearly exhibited, bed after bed, from the Bembridge limestone down to the sands at the base of Headon Hill, and in Alum Bay from those sands to the bottom of the plastic clay.

In this fine display not only are the strata clearly shown, but their fossils also are exquisitely preserved and exposed to view. I shall proceed to enumerate the order of beds and their contents, mentioning them in descending order in accordance with the plan of this paper, and therefore commencing at the *Black band* which I have described as forming the base of the Hempstead series.

Beds of the Bembridge series (in descending order).

The *Black band*, dividing the Bembridge from the Hempstead series.

1. Green marls, with scattered individuals of *Paludina lenta* and *Melanopsis*, and a seam of crushed shells, with small univalves and fish vertebræ. Vertical root-like bodies in marl beneath the black band.

2. Zone of large *Paludina lenta*, with ferruginous concretions.

3. Clays with few fossils; scattered individuals of *Melania muricata*.

4. Zone of *Paludina lenta*, as in the uppermost part of the Bembridge marls at Whitecliff.

5. Stiff brownish-green clays, with few fossils.

6. Bluish clays; fossils few; a belt of *Melania*.

7. Pale bluish clay, with patches of lignite and carbonaceous streaks.

8. Bands of pyritiferous nodules, with *Melania turritissima* and *M. Forbesii*.

9. Greenish blue clay with occasional lignite; bands of *Paludina lenta*, especially above, and seeds.

10. Pyritiferous and shelly band full of *Melania turritissima*.

11. Pale clays and shales.

12. Greenish clay, with *Cerithium mutabile*, *Melanopsis carinata*, and *Paludina lenta*.

13. Bluish green clay, with *Cyrena obovata* and occasional specimens of *Cerithium mutabile.*

14. Band of carbonaceous clay and lignite, with *Melanopsis carinata* and *Melania;* also a *Planorbis* like *P. lens.*

15. Pale bluish green clay, with occasional belts of *Melania turritissima* and *M. muricata.*

16. Zone of *Melanopsis carinata* and *Melania muricata,* interspersed with a large variety? of the latter.

17. Belts of *Melania muricata* and *turritissima, Melanopsis carinata,* and *Paludina lenta* in greenish marls, with fish bones.

18. Zone of *Melanopsis carinata, Paludina lenta,* and *Melania muricata.*

19. Greenish clay, with occasional specimens of *Melanopsis carinata* and *Paludina lenta.*

20. Zone of *Melania muricata* and *Cyrena obtusa,* in clays. In this band occurred the only specimen of the beautiful *Cerithium Austenii* met with, also a Corbula-like shell, and a *Lyonsia?*

21. Zones of *Melania turritissima,* &c.

22. Pale green clays with vegetable markings, zones of *Melania turritissma,* and occasional *Paludina lenta.*

23. Verdigris-green clays, with occasional zones of *Cyrena semistriata,* var., and *C. obovata.*

24. Zones of *Cyrena semistriata* var. and *obovata* in green clay.

25. Mottled green and white clay, without fossils.

26. Band of *Cyrena semistriata,* var.

27. Mottled pale whitish clay, without fossils.

28. Mottled green clays, with occasional *Melania muricata.*

29. Dark clays, with *Cyrena obovata,* valves mostly separated.

30. Bed (a foot thick) composed almost entirely of broken *Cyrenæ.*

31. A band of more or less distinct septarian stone.

32. Greenish clay, with lines of *Cyrena semistriata* var.

33. Clays, without fossils.

34. Zone of *Melania muricata*, with occasional *Cyrena obovata*.

35. Dark clays, with zone of *Cyrena pulchra*, valves very perfect, but mostly single, and of all ages; *Cyrena semistriata*, var., and small specimens of *C. obtusa*; also *Melanopsis fusiformis*, and small *Hydrobiæ*.

36. Dark clays without fossils.

37. Zone of *Cyrena semistriata*, var., *C. obtusa*, and *Cerithium mutabile*.

38. Imperfect band of septarian clay.

39. Pale blue clays, with scattered *Cyrena obovata* and *Melania muricata*.

40. Sandy bed, with *Cyrena semistriata* and *Ostrea*.

41. Whitish marl.

42. Bembridge limestone, forming the ledge at Hempstead Point.

I have not given the thickness of the individual bands, as circumstances did not permit of so detailed a measurement, but the total thickness from the limestone up to the Black band is nearly 75 feet.

The rise of the marls from the shore on the western side of the synclinal is concealed by falls from the cliff above. At the Yarmouth end of Hempstead Hill, however, they are partially exposed in the very low cliff along the shore. They rise at a very slight angle, this being the short arm of the synclinal. A band of ironstone abounding in *Paludina lenta* and *Melanopsis carinata* rises below the wood towards Yarmouth, and the muddy shore is strewn with fragments of it. The lowness of the coast, and the extensive denudation near the town prevents more being seen. In the Freshwater peninsula, about 20 feet thickness of marls in one place, but usually much less, is seen capping the limestone above Sconce Point, and following the slope of the beds. *Cyrena semistriata* var., *Cyrena obtusa*, *C. obovata*, *Melania muricata*, *Melanopsis fusiformis* and *Serpulæ*, are the fossils that occur in it. The marls are also seen resting on the limestone on the hill above More Green, between Norton and Freshwater, with abundance of *Cyrena semistriata* var.

but most of the specimens in a broken and crumbly condition. At the northern extremity of the summit of Headon Hill, before the truncation by denudation of the calcareous marls that are the equivalents of the Bembridge limestone, some three or four feet of the superincumbent marls containing their characteristic fossils are preserved.*

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b'. Fossils of the Bembridge Series.

Shells.

Murex. (ribbed species). Hydrobia—sp.

Natica labellata. Lam.

Cerithium mutabile. Lam. Forbes. Pl. iii., f. 12.
„ Austenii. Morris. Pl. iii., f. 11.

Melania muricata. Wood.
„ costata. Sow.
„ turritissima. Forbes. Pl. iii., f. 14.
„ fasciata. Sow.
„ muricata. Wood. Pl. iii., f. 16.
„ excavata.† f. 3, f. 17.
„ Forbesii. Morris. Pl. iii., f. 15.

Melanopsis fusiformis. Sow.
„ carinata. Sow.
„ brevis. Sow.
„ subulata. Sow.

Paludina lenta. Sow. Brander.
„ globuloides. Forbes, MS. Whitecliff.
„ orbicularis. Sow., M. C., t. 175, f. 2.

Planorbis oligyratus. Edw. Eoc. Mol., t. xv., f. 3. Sconce. Whitecliff.
„ discus. Edw. Eoc. Mol., xv., f. 7. Sconce. Whitecliff.
„ rotundatus. Brong. Edw. Eoc. Mol., xv., f. 4. Whitecliff. Char. of vth group.
„ Sowerbii. Brong. Edw. Eoc. Mol., t. xv., f. 9. Do.
„ obtusus. Sow., t. 140, f. 3. Edw. Eoc. Mol., t. xv., f. 1. Sconce. Whitecliff.
„ platystoma. Wood. Edw. Eoc. Mol., t. xv., f. 2. Sconce.

Limnæa longiscata. Br. Sow. M. C., t. 343. Edw. Eoc. Moll., t. xiii., f. 3. Sconce. Whitecliff.

Succinea Edwardsi. Forbes.

Craspedopoma Elizabethæ. Edw. Eoc. Mol., t. xvi., f. 14.

Cyclotus cinctus. Edw. Eoc. Mol., t. x., f. 1. Headon Hill.
„ nudus. Edw. Eoc. Mol., t. x., f. 11.

Clausilia striatula. Edw. Eoc. Moll., t. xi., f. 6. Sconce.

Pupa perdentata. Edw. Eoc. Moll., t. xi., f. 7. Sconce.
„ oryza. Edw.

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* For further details see notes by Mr. Bristow, p. 120 to 127.

† This, though quoted here and elsewhere as a species, is a var. of *M. muricata* (p. 151).

Achatina costellata. Sow. M. C., t. 336. (*Young*) 528, f. 1 [Glandina]. Sconce. Headon. Binsted.

Bulimus ellipticus. Sow. M. C., t. 337. Headon. Sconce. Binsted.
„ heterostomus. Edw. Sconce.

Helix occlusa. Edw. Eoc. Moll., t. x., f. 10. Headon Hill. Sconce. Whitecliff Bay.
„ labyrinthica. Say. Edw. Eoc. Moll., t. x., f. 7. Whitecliff Bay.
„ D'Urbani. Edw. Eoc. Moll., t. x., f. 5. Headon Hill. Sconce.
„ Vectensis. Edw. Eoc. Moll., t. x., f. 8. Headon Hill. Sconce.
„ globosa. Sow. M. C., t. 170. Sconce.
„ omphalus. Edw. Eoc. Moll., t. x., t. 5. Sconce.
„ tropifera. Edw. Eoc. Moll., t. x., f. 3. Headon.
„ Headonensis? Edw.

Cyclostoma mumia. Lam. Desh. C. F., t. 7. Brading Harbour. Calc. gros., Grès de Beauchamp, Gypse.

Ostrea Vectensis. Forbes. Pl. iii., f. 9.

Mytilus affinis. Sow. Forbes. Pl. iii., f. 7. Whitecliff Bay.

Modiola ?

Arca Websteri. Forbes. Pl. iii., f. 8.

Unio.

Nucula similis. Sow., M. C., t. 142, f. 4. Forbes. Pl. iii., f. 5.

Lucina Thierensi. Hébert. L. albella Nyst. Coq. Foss., t. 5, f. 8.

Cytherea incrassata. Desh. C. F., t. 22, f. 1. Sow., t. 155.

Cyrena pulchra. Sow., t. 527. Pl. iii., f. 1.
„ semistriata. Desh. Var. Pl. iii., f. 2.
„ (semistriata. Var.)
„ transversa. Forbes. Pl. iii., f. 6.
„ obtusa. Forbes. Pl. iii., f. 4.
„ obovata. Sow. M. C., t. 162, f. 4–6

Corbula pisum. Sow.

Mya (Panopæa) minor. Forbes. Pl. iii., f. 3.

Cirripeda.

Balanus unguiformis. J. de C. Sow.

Reptiles.

Trionyx incrassatus. Owen. Foss. Rept.

Mammals.

Palæotherium crassum. Cuv. Owen. Fos. Mam. G. Tr. 2d. Ser., vol. vi., t. 4, f. 7.
„ minus. Cuv. Owen.
„ magnum. Cuv.
„ medium. Cuv.

Anoplotherium commune. Cuv. Owen.
„ secundarium. Cuv.

Chœropotamus Cuvieri. Owen. G. Tr., vol. vi., p. 41, t. 4, f. 1–3.

Dichobune cervinum. Owen. G. Tr., vol. vi., p. 45.

Plants.

Chara medicaginula. Brong.
„ tuberculata. Lyell.

b'. Foreign Homologue of the Bembridge Limestone.

The constancy of general features and importance of these beds in the Isle of Wight are such as to suggest the probability of our finding on the continent some close resembling equivalent, and our search is naturally directed in the first instance to the Paris basin, the freshwater limestones of which have long been famous. The contents of the "Travertin supérieur," or uppermost of the three important freshwater limestones of Paris, we have already seen to be such that it is not with it we can compare the Bembridge limestones. A possible analogue for the "Travertin moyen" I have just ventured to indicate, and if the view I have taken of the relations of the Bembridge marls to the Paris gypseous beds be accepted, then it is to the "Travertin inférieur," or "calcaire siliceux," that we may fairly turn and, as I believe, with confidence and success.

My personal opportunities for comparing the Bembridge limestone with the "Travertin inférieur" (of Charles d'Orbigny), calcaire silicieux of many authors, or fifth stage of the fifth group ("calcaire lacustre moyen") of d'Archiac,* have been limited to the examination of hand specimens and a visit to a single section. At present, this part of the series is, I believe, not clearly exposed in the immediate vicinity of Paris. The point at which, in company with Mr. Prestwich, in September 1853, I saw it, was near the village of Autremont, between Creil and Chantilly (Dép. de l'Oise).

In the sandpits there, pure white sand, containing no fossils, and belonging to the "Grès moyen," or "Grès de Beauchamp," is excavated for purposes, I believe, similar to those for which the Headon Hill sand is employed. This sand contains concretions of greenish white sandstone, becomes dusky upwards, and passes into white marls, with the intervention of a brownish band of sand a foot and a half

* Histoire des Progrès de la Géologie par A. D'Archiac, T. ii., p. 552. See also Graves's Essai sur la Topographie Géognostique du Département de l'Oise, p. 489 et seq. The minute Paludinæ of this part of the French series are P. terebra and P. atomus of Deshayes.

thick. The sandy marls above it are about two feet in thickness, and are capped by a bed of travertin, which in the place where it was exposed in greatest thickness, measured nearly 12 feet. It is a white, often soft, marly limestone, with harder concretions. Fossils are scarce in it, a minute *Paludina* being most common, and in one fragment I found a *Helix labyrinthica*, a shell I believe new to France. As the limestone has been most denuded here, and evidently from the surface of the soil, the beds exposed are probably only the lower portions of the series, for among heaps of broken stones from this neighbourhood by the roadsides in the vicinity we found fragments of a limestone rather more compact and containing *Limnæa longiscata* and *Cyclostoma mumia*.

Some specimens of very white marls from immediately below the gypsum series at Nanteuil, shown to me by M. Deshayes, were full of small lentiform *Planorbides*, *Limnæa longiscata*, *Cyclostoma mumia*, and a minute slightly elongated *Paludina*, accompanied by occasional nucules of *Chara*, among which I thought I could distinguish *Chara tuberculata*.

In the fine series of rock specimens contained in the cabinets of the galleries at the Jardins des Plantes, I observed an example classed "Travertin inférieur," from the environs of Reims, which, had it been placed in my hands in England, I would not have hesitated, on account of the striking resemblance of both mineral character and fossil contents, to have declared as a fragment of the Bembridge limestone at St. Helen's. It had the same warm, yellow hue, peculiar texture, and association of fossils, the mass being crowded with casts of *Limnæa longiscata* mingled with *Cyclostoma mumia* and a minute *Paludina*. In a neighbouring specimen the shells were *Planorbis rotundatus*, a minute *Paludina*, *Limnæa longiscata*, and some *Paludina globuloides*.

In the section of the Montagne de Ludes, given by M. Natalis Rondet, in his "Etude Géologique de Pays de Reims" (1843) the "calcaire lacustre silicieux" is stated to be separated from a stone with marine shells by marls con-

taining compressed *Limnææ* and *Cyclostoma mumia*. *Limnæa longiscata* abounds in the lower, *Planorbis rotundatus* in the middle, and *Cyclostoma mumia* in the upper portion of the limestone, in which occur also, especially in a very compact lowermost portion, small *Paludinæ* and *Gyrogonites*. The limestone rests on some two yards of greenish sandy clay, without fossils. A comparison of this statement with my description of the St. Helen's section will show how striking is the analogy.

M. Charles D'Orbigny, in his "Notice Géologique sur les Environs de Paris," 1838, has given an account of the five sections of the Travertin inférieur displayed during the cutting of the railway of Monceaux, when a thickness of nine metres was exposed. In this section beds of sand, marl, and clay established a passage from the grès de Beaular to the stronger calcareous beds, of which there were several alterations. *Cyclostoma mumia*, *Limnæa longiscata*, *Planorbides* of more than one species, minute *Paludinæ*, nucules and stems of *Chara* (called *C. medicaginula* in the memoir cited), and impressions of the leaves of *Typha* were the fossils observed. The highest of the principal beds of limestone was sometimes siliceous, sometimes marly, and in places brecciated; and often contained nodules of menilite passing into "silex nectique," and was surmounted by beds of marl and "magnesite," covered by beds of the gypseous series. The arrangements in this section were evidently strikingly analogous to those of the Bembridge limestone beds.

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c. Osborne (or St. Helen's) Series.

Between the Bembridge limestone and the brackish-water beds with *Potamomyæ* that terminate the Headon series, a considerable thickness of strata intervenes, deserving of a distinctive appellation on account of their mineralogical and palæontological peculiarities, and of their holding an intermediate character between the middle and upper eocene strata. This set of beds I termed in my communication

to the Geological Society the "St. Helen's beds," on account of the conspicuous features presented by them between St. Helen's and Ryde. This name, however, is objectionable, both because they are not seen in connexion with the Headon beds in that area, and nowhere within it do they occupy a sufficiently superficial space, so as to be indicated on the map. Moreover the name "St. Helen's," being much better known in connexion with other and distant towns, is inconvenient. At the time I applied it, however, I did not know of a better locality from which to indicate a type for these strata. Since then, through the gracious permission of Her Majesty, I have been enabled to examine the geology of Osborne; and within that limited area, and only there, have I found the strata in question occupying a superficial area. Moreover, in the cliffs on the shore a little to the west of Osborne they are seen in conjunction with the Upper Headon series, whilst a little to the east they are seen underlying the Bembridge limestone. The lithological peculiarities of this series are remarkably displayed in the cliffs and grounds of the royal domain: for these obviously excellent reasons, I am consequently, induced to apply to them the name of "Osborne series," as truer, more typical, and less likely to lead to confusion than the denomination provisionally given them last year.

*Osborne Series in Whitecliff Bay.**

The junction of the uppermost Headon beds with the strata of this series is strongly and conspicuously marked in this locality by the sudden retirement of the cliff, the former beds standing out and being abruptly truncated, whilst the latter, owing to their softer and more clayey nature, form a grassy or broken slope, subject to muddy landslips. This slope extends from their commencement to the base of the Bembridge limestone, and almost everywhere the details of the strata composing it are concealed. Their total thickness is very nearly 100 feet. In the slips dark shaley clays and bright red and blue variegated clays occur. At about 36 feet above the top of the Headon beds a thin

* See Vertical Section, Plate 10.

band of yellow limestone scantily fossiliferous (*Helix occlusa*, *Planorbis discus*, *Limnæa longiscata*, and bones of a fish) is slightly exposed. The equivalent of this band we shall find well marked in the next locality. Some hard gritty bands occur in the upper portion of this slope, not far below the base of the Bembridge limestone. More bands appear to mark the commencement of the strong sandstones seen at the same horizon more to the north.

*Osborne Series between St. Helen's and Ryde.**

The coast between Brading Harbour and Ryde presents a series of wooded slopes and occasional sections, and on the shore rocky ledges occur, especially below Seafield and from St. Helen's to Nettlestone, a portion of the interval between Seafield and Nettlestone Point being free from rocks, and forming a long slope inland. The shore at this point, when the sand is removed, is composed of clay. At the Watch-house Point, below St. Helen's, the Bembridge limestone forms the shore, but rapidly rises northwards and forms a great arch, so as to bring the inferior beds to view; the centre of this arch is somewhere about the saltern near Seafield. The base of the Osborne series, thus exposed, is not, however, to my knowledge seen, nor among the fossils cast on shore by the waves have I met with any that would indicate an exposure of the Headon beds below. A fault running N.N.E. and S.S.W. brings up the Nettlestone division of the Osborne beds opposite the Priory. This fault is an upthrow, and just skirts the shore in such a manner as to present some very puzzling appearances at first glance.

The strata along this section are in many places beautifully shown, and present peculiarities not seen elsewhere in this series in the island. The differences between the upper portion of them and the lower are considerable, and admit of a convenient distinction. I have termed the former of these two divisions the "St. Helen's Sands," and the latter "Nettlestone Grits."

The succession of beds, in descending order, is as follows:

* See Vertical Section, Plate 10.

(1. St. Helen's Sands.)

1. Immediately under the lowest bed of the Bembridge limestone (here divided into three bands) occurs a band of dark greenish carbonaceous clay, breaking with a sub-conchoidal fracture, and forming a truncated stratum in the cliff; 1 ft. 6 in.

2. Pale greenish white and yellowish marls, with patches of calcareous sand and comminuted shells; also argillo-calcareous nodules of various sizes. In this bed a characteristic fossil, *Melania excavata*, occurs in abundance, and has the shell preserved. 8 ft.

3. Pale green, yellowish, and white sands, hardening into sandstones, with large lenticular siliceous concretions and spongoid bodies. *Melania excavata* is plentiful here and there, and occasionally occurs crowded. A small *Hydrobia* is also present; and from a mass of loose sand I extracted a *Helix* with the shell entire, apparently *Helix omphalus*, but unfortunately destroyed the specimen. 14 ft.

4. Greenish yellow irregular and concretionary sandstone, with siphonoid or fucoidal bodies; 3 ft.

5. Yellowish and whitish sands, with a line of purple (manganese?) nodules and siliceous concretions below; 9 ft.

6. Laminated white sands, indurated into quartzose flags above and below; the upper surface exhibiting strong current marks. This band is remarkable for its contents, including *Limnæa longiscata*, a shorter species of *Limnæa* resembling *L. pereger*, *Planorbis obtusus*, and *Melania excavata*, all in the condition of casts. The fossiliferous portion is in the lower part. 3 ft.

7. White sandy clay, with a band of broken *Cyrenæ*; 2 ft.

8. Greenish blue clay, seen on shore at low water, containing *Cypridæ* and traces of *Melania* and *Cyrenæ* (*C. obovata?*). The thickness may be estimated at 8 ft.

(2. Nettlestone Grits.)

9. Imperfect softish bright yellow limestone, riddled by minute confervoidal cavities, hardening into a building stone

by exposure to the weather. Not very fossiliferous, but contained *Limnæa longiscata*, a large full-bodied species, *Hydrobiæ*, and *Chara* nucules (*Chara Lyellii*). This limestone may be seen opposite the boathouse near Nettlestone, but as it is much carried away is not evident except at low water. It is the equivalent of the band in the slope at Whitecliff Bay. 2 ft.

10. Bright yellow and white marly clays, with patches of greenish sand, filled with argillo-calcareous nodules of various sizes. In these nodules the *Melania excavata* abounds. These clays do not appear to exceed a thickness of 4 ft.

11. Freestone or rag, with siliceous concretions passing into a grit. A great part of this bed is made of comminuted univalves, the fragments smaller and finer below. In the middle portion occur bands of unbroken *Paludina lenta*. This is the bed of which portions are thrown up in the line of the fault below Summerhouse Point, where it is very conglomeratic and includes pebbles of flint. Similar pebbles are seen here and there in it at Seafield. It is used for a building stone there, and for making the groins on the shore east of Ryde. In these beds the casts of *Melania excavata* occur in myriads, also *Paludina lenta*, *Hydrobiæ*, a short *Melanopsis*, apparently *M. brevis*, *Melanopsis carinata*, *Planorbis rotundatus* (scarce), *Limnæa longiscata*, and the short-spired species, vertebræ of fish, and fragments ofturtle. 8 ft.

In a block in a neighbouring wall I observed impressions of a small and peculiar *Cerithium*, and remains of a large shell, apparently *Achatina costellata*.

12. Softer and whiter sandstone, with frequent calcareous concretionary bands, containing *Limnæa longiscata*, and separated by a thin layer of compact sandstone with impressions of *Unio*, form a compact flagstone with fucoidal impressions; 4 ft.

13. Shelly sandstones, often studded with angular flints; 6 in.

14. Soft calcareous stone, with *Paludina lenta;* 6 in.

15. Flags of sandstone, with large ripple marks; 6 in.

Osborne Series between Ryde and Cowes.

In the cliffs and on the shore west of Wootton Creek the Bembridge limestone rises above variegated red and green marls and clays belonging to this group, though, owing to the land slips, the minute arrangements of the strata are not easily to be made out. Here, however, we have an approach to the peculiar characters of the upper division of these beds as displayed at Cliff End.

The slips and slopes at the eastern portion of the shore at Osborne show similar mottled red and green clays, overlying a limestone composed of broken shells and containing *Melania costata* and *Melanopsis brevis*. On the shore lie flags of sandstone with fucoidal markings, and blocks of a greenish sandstone containing casts of *Paludina lenta*, often weathered in high relief, *Melania excavata*, and a large-bodied *Lymnæa* of considerable size. Among the marls are layers containing entire shells of *Melanopsis carinata*, small *Paludinæ* or *Hydrobiæ*, and *Chara* nucules in abundance. This appears to be an excellent locality for fossils.

Opposite the lawn that stretches down to the sea in the grounds at Osborne, there are no hard beds or rock masses exposed on shore, but immediately to the west of the landing pier are strata of exceeding interest, for here we see marls and shales belonging to the upper part of the Headon series. On the shore by the pier outcrops of beds of tenaceous greenish blue clay are exposed, full of *Cyrena obovata*, mingled with *Paludina lenta;* and in the clay beds in which the foundations of the sea wall are placed are *Cerithia*. At a height of about 20 feet above the shore is a stratum of ragstone, an imperfect limestone, two feet or more thick, thickening more westwards and thinning out eastwards. The ragstone makes but bad lime. Higher up is a sandy limestone and bands of comminuted shell stone, separated from the rag by marls. In fragments of the limestone I observed numbers of *Paludina lenta*, accompanied by peculiar large-bodied *Limnææ* of considerable size, and occasional lines of *Uniones*, somewhat resembling *U. Solandri*

in outline, but a larger shell. The *Paludinæ* were often lying loose in their cavities, and had their shells frequently preserved. I found portions of a large *Planorbis*, apparently *P. euomphalus;* also *Planorbis obtusus*, and another, *P. platystoma. Melania excavata* and lines of broken *Cyrenæ* occurred in a gritty band. Pale blue and purple shales, about 10 feet thick, capping yellow sands that become white eastwards, surmount the grits, and are succeeded by ferruginous marly and stony bands containing casts of *Paludina lenta*, hollow and having their cavities lined with crystals of calc-spar, *Limnæa* and *Planorbis*. Dark shales, with partings of *Cyrena obovata*, form the highest portions of the broken cliff. The details of this important section are obscured by land slips and cultivation, but it is evident that here the ground to the surface is occupied by typical beds of the Osborne series, those on the western side of the lawn belonging to the lower or Nettlestone division, whilst eastwards we find the members of the higher or St. Helen's group. The Osborne section is peculiarly interesting for the link that it affords between the very different aspect of these beds at Cliff End as compared with those at St. Helen's.

Osborne Series at Cliff End, near Sconce.

The sections at this point, though often obscured by falls, are extensive, and for the most part clear; they have, however, met with undeserved neglect, owing to the superior perspicuity and more interesting fossil contents of the Headon beds that succeed to them in Colwell Bay. Yet, although in perfect sequence and conformity with the latter, they are in some measure physically distinguished from them, so much so that the only detailed (and most excellent) published section of the strata exposed in Colwell Bay—that by Dr. Wright*—commences very nearly at the point of junction, apparently on account of physical differences, for at the time that section was made the arrangements and classification maintained in this memoir were unthought of.

* Ann. N. Hist. 2d Ser. 1851, vol. vii. p. 14.

The Osborne beds in this locality were carefully examined by Mr. Bristow and myself in 1852. I revisited them twice, once in spring and once in autumn, to observe their changeable aspects, in 1853, and at my last visit was accompanied by several very able pupils of the School of Mines. Three of these gentlemen, Messrs. Burbidge, Minton, and Featherstonhaugh, undertook, as an exercise, the construction of a detailed section of the Colwell and Tollands Bay beds from the Sconce limestone to the Headon sands. I have availed myself of their notes in the following description. Even within a few yards the same bed may vary considerably in this locality; and when during winter the softer clays slip and roll out in the shape of mud glaciers, there is considerable difficulty attending the determination of the relative importance of the several strata.

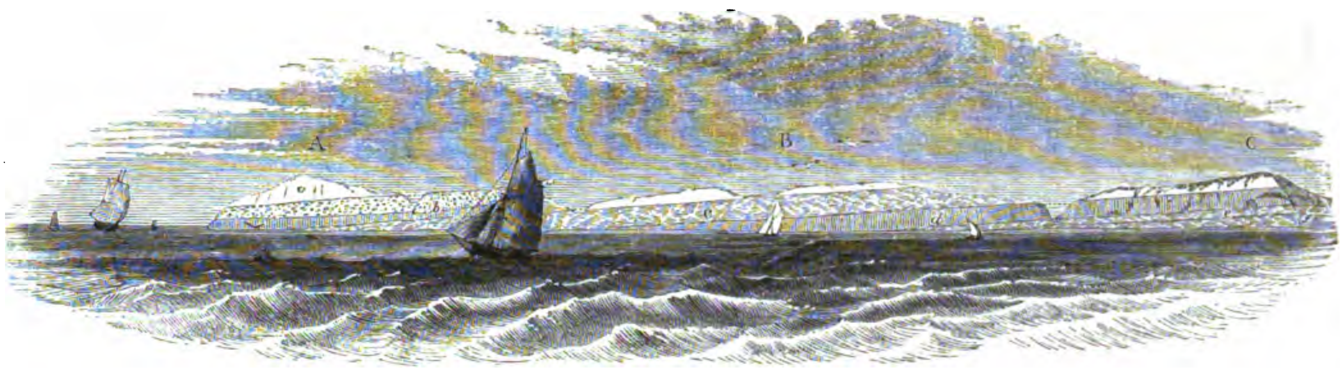
The beds rise from below the Sconce limestone, near the site of Worsley's tower, and crop out by the first chine in Colwell Bay beyond Cliff End. The measurements of their total thickness, in consequence of the accidents alluded to, differ considerably, ranging from 46 to 60 feet. The latter is nearest the truth; but in either case there is evidently a considerable thinning out of this series as we proceed westwards.

1. Immediately below the Sconce (Bembridge) limestone, which in many places is soft and marly at its base, are bluish sandy and marly clays, with bands (not constant) of *Cyrena obovata;* about 10 feet.

2. A succession of from 25 to 30 feet of various coloured marls, with nodular concretions, in which occasionally fossils occur, and then bands of argillaceous limestone. This portion of the beds is much given to form land slips. It was subdivided by my pupils as follows: 1. Red marls. 2. Reddish marlstone. 3. A thin band of limestone, with *Paludina* and *Limnæa*. 4. Green marl. 5. Red and yellow marl. 6. Greenish grey clay. 7. Grey marl. 8. Greenish clay (6 ft. thick); and, 9. Grey marl.

3. Dark grey laminated clays, very fossiliferous, divided in the centre by a strong but thin band of ironstone. In the portion above this band *Cypridæ* abound; the species is

XII.



A. Cliff End and Sconce Point. B. Colwell Bay. C. Warden Point.

a Sconce (Bembridge Limestone). *b.* Osborne series. *c.* Upper Headon series. *d.* Middle Headon series. *e.* Lower Headon series.

an elongated form (*Candona Forbesii.*) There are traces also of remains of insects. In the ironstone band are beautifully preserved examples of *Paludina lenta*, *Melanopsis carinata*, and *Melania costata*. In the lowest portion, crushed shells, partly apparently *Cyrena obovata*, are plentiful; *Paludina lenta* and *Melania costata*, the latter shell most plentiful towards the base of the bed. 7 feet.

4. Reddish and bluish calcareous clays, with pale green nodular concretions containing shells, passing below into red and green mottled clay, and becoming a white marl at the base. Fragments of turtle occur in this bed. In the nodules I found *Limnæa longiscata*, a small *Hydrobia*, and *Paludina globuloides*. 10 feet.

5. Dark blue and brown clays alternating with concretionary ironstone bands, and bands in red and green marls; 6 feet. *Limnæa longiscata* and *Paludina globuloides* occur, with *Cyrena obovata* in the uppermost part of this band, whilst below *Potamomyæ* and *Paludina lenta* alternate along with a *Serpula*, and mark the passage into the Upper Headon strata.

The distribution of fossils as stated above was noted close to Cliff End, but appears to vary considerably at small distances. In some of the mottled red and green clays slipped from the upper part of the series, numerous scattered *Paludina lenta* occur. More than one species of *Hydrobia* and the large full-bodied *Limnæa* noticed at Osborne and Seafield are met with in the pale green nodular concretions washed out of these beds and scattered along the shore, *Paludina globuloides* occur in some of the slipped clays with its shell preserved. The abundance of *Melanopsis carinata* is very striking.

Osborne Series at Headon Hill.

Between Cliff End and Headon Hill the denudation has stripped away all traces of these beds, but in the upper portion of the hill itself they are preserved in their integrity, though not exhibited in perfect clearness, their softer portions being hidden by broken slopes. At the same time, their

thickness in this locality is rather greater than in Colwell Bay. The sections, in descending order of strata, may be stated as follows:

1. Whitish marls, passing downwards into red and blue mottled clays (more red than blue), with occasional hard and gritty bands and rows of nodular greenish concretions, in which traces of shells and turtle-bones occur. Portions of turtle are also found in the clay. Among the shells in the concretions I found *Planorbis discus* (distinctly this species), a new *Limnæa* resembling *pereger*, *Limnæa longiscata*, and a fuller bodied species, *Planorbis obtusus* and *oligyratus*, and a *Paludina* apparently different from *P. lenta*. Comparatively few nodules, however, contained entire fossils, and those in them were always in the state of casts. These marls and clays may be estimated at between 30 and 40 feet. There is no locality here where they can be fairly measured.

2. Grey shaly clays, with crushed *Paludina lenta* and fish vertebræ, separated by a thin band of ironstone from grey shales with *Paludina lenta*, *Melanopsis carinata*, and *Melania costata*; 7 feet.

3. Yellow, red, and blue sandy clays; 3 feet.

4. Strong concretionary yellowish limestone, with siliceous concretions sometimes of considerable size, and used for building. Fossils are comparatively scarce in this stone. *Limnæa longiscata* is most common. I found also *Planorbis euomphalus* (very scarce, however), *Planorbis lens*, and *Paludina lenta*. This bed, which is no less than 18 feet thick here, disappears almost completely only two miles to the north.

5. Greenish white calcareous clay; 4 feet.

6. Sandy ferruginous band, 2 feet, resting on

7. Blue and yellow clays and marls, passing into grey laminated clays, with crushed *Paludina lenta*. These rest on Potamomya clays, and are rather more than 16 feet in thickness.*

* For further details see notes by Mr. Bristow, p. 127 to 130, and Vertical Section, Plate 10.

c.' Fossils of the St. Helen's or Osborne Series.

Cerithium. Small sp.
Melania excavata. Forbes. (Pl. iii., f. 17.)
„ costata. Sow. M. C., t. 241, f. 2.
Melanopsis brevis. Sow. M. C., t. 523, f. 2.
„ carinata. Sow. „ „ f. 1.
Paludina lenta. Brander.
„ (like lenta.) ?
„ globuloides. Forbes, MS.
Hydrobia.
Planorbis discus ? Edw.
„ obtusus. Sow. M. C.
„ rotundatus. Sow.
„ euomphalus. Sow.
„ platystoma. Wood.
„ oligyratus. Edw.
Limnæa longiscata. Sow.
„ ? like longiscata, but fuller bodied.
„ ? nov. sp.
Achatina costellata. Sow.
Helix occlusa ? Edw.
Unio.
Cyrena obovata. Sow.
Potamomya plana. Sow.
Candona Forbesii. Jones, Pl. vii., fig. 22.
Cytherideis unisulcata. Jones, Pl. vii., fig. 23.
Cytheridea Mulleri. Jones, Pl. vii., fig. 27, 28.
Chara Lyelli. Forbes. *C. medicaginula,* Geol. Trans., vol. ii., t. 13, f. 25.

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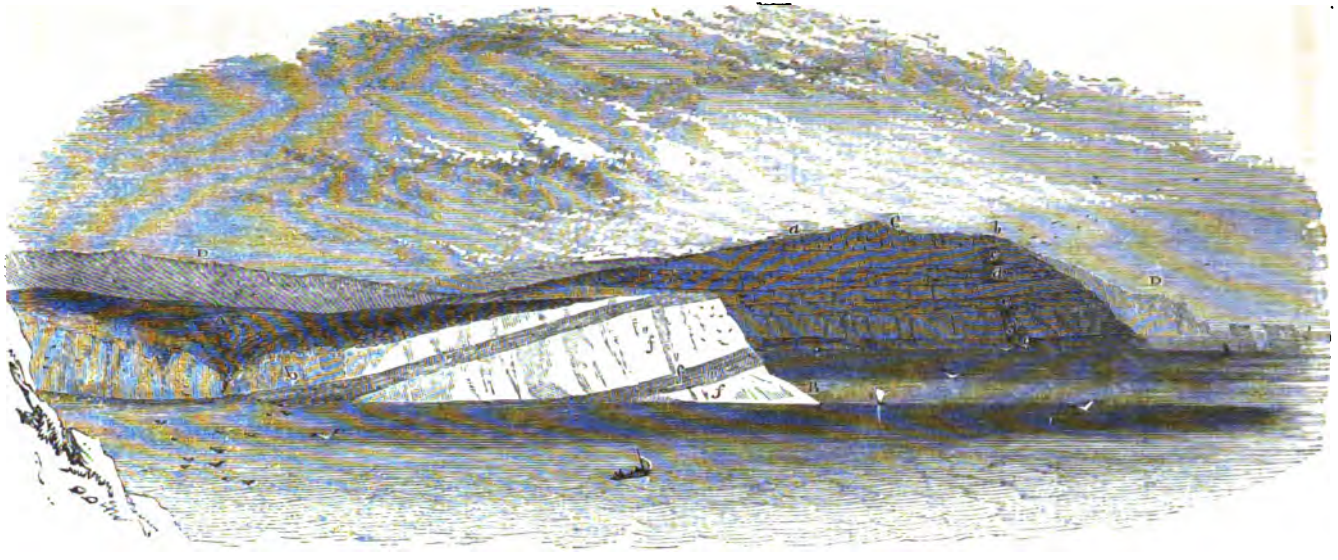
d. The Headon Series.

These beds are 170 feet thick, or thereabouts. They are seen best at Headon Hill, in Colwell Bay, at Whitecliff Bay, and their lower divisions only at Hordwell. (Woodcut XIII.)

Numerous fossils are common to all the beds of the Headon series. Everywhere *Planorbis euomphalus* characterizes their freshwater bands, accompanied by peculiar *Limnææ. Potamomya plana* and *Cerithium cinctum* abound in the brackish-water belts; and *Cytherea incrassata,* accompanied by many sea-shells, some peculiar, more of them ommon to the Barton series, occur in the marine division.

XIII.



A. Colwell Bay.

a. Gravel.
b. Branch of Bembridge limestone.

B. Warden Point.

c. Osborne series.
d. Upper Headon series.

C. Headon Hill.

f' } Middle Headon series.

D. D. Chalk range.

f'', *f'''* } Lower Headon series.
g. White sands.

The species of *Chara* are distinct. The fossils of this group of beds are so well known that no detailed remarks are requisite in the present communication.

The Headon series may be sub-divided into:—

1. Upper. { Uppermost marls, with *Cerithium lapidum?* / Upper Headon freshwater and brackish beds.
2. Middle; Headon intermarine.
3. Lower Headon fresh and brackish-water beds. *Cyrena cycladiformis* is a marked fossil of this division.

(1. *The Upper Headon Beds.*)

These form the greater part of what was usually termed the "Upper Freshwater Formation" of Webster, and of subsequent writers, and in Headon Hill were confounded with the superincumbent beds of the St. Helen's or Osborne series. The strongest masses of the freshwater limestone in Headon Hill belong to this section, but a little way to the north they thin out considerably, and are represented in Whitecliff Bay by a few very thin and inconspicuous sandy, concretionary bands. It was the strength of these, and of the limestones of the lower beds at Headon Hill, that seems to have misled former observers into the belief that all the conspicuous limestones in the island belonged to the Headon series. The Upper Headon beds consist in their highest part of brackish-water bands, abounding in *Potamomyæ*, and a large variety of *Cyrena obovata*. At Cliff End they contain a *Cyrena*, which, though usually regarded as *Cyrena pulchra*, appears to be distinct from that fine species. Great numbers of the *Potamides margaritaceus Sow.* (*C. elegans Desh.*) occur in these beds. The shells of the fresh-water limestones are the same as those of the Lower Headon beds, with the exception, perhaps, of a large *Paludina*, and the so-called *Bulimus politus* (*Hydrobia*). *Melania muricata* abounds.

(2. *The Middle Headon Beds.*)

These consist of what have been usually called "the Upper Marine Formation." At Headon Hill this division mainly indicates brackish-water conditions, although oysters, *Cytherea incrassata*, *Nucula deltoidea*, *Natica depressa*, and *Buccinum labiatum* are sufficiently common. Immediately above and below, or rather forming the uppermost and lower portions of this section, are brackish-water beds, abounding in *Potamides ventricosus*, *P. concavus*, *P. cinctus*, also in *Neritina concava* and *Nematuræ*. At a short distance, as at Colwell Bay, the same bed assumes a marine character, and presents large banks of oysters with numerous marine shells, many of them of Barton species. It was this difference between the conditions at Headon Hill and Colwell Bay that misled M. Hébert. Judging from detailed sections, especially those published by the Marchioness of Hastings and Dr. Wright,* the marine character of this division is fully maintained at Hordwell, though in beds of a very inferior thickness. Respecting that locality, however, there is a serious discrepancy in the statements of the describers. The section made by the Marchioness of Hastings appears to me to be most correct, and to agree most accurately with the arrangements of the beds on the opposite side of the Solent. At Whitecliff Bay the main character of the Middle Headon beds is still more strongly marked, and the thickness of purely marine deposits much greater than westwards.

(3. *Lower Headon Beds.*)

These consist of fresh and brackish-water beds, abounding in fossils which, for the most part, are identical with those of the upper division. At Headon Hill and Colwell Bay there are thick limestone bands in this part of the series, but at Whitecliff Bay all the beds are clays and marls. They are more varied at Hordwell, where the greater part of the fluvio-marine beds there seen belongs to the Lower Headon series. It is in these beds, and at that locality, that numerous remains of *vertebrata* have been found, especially

* Ann. and Mag. N. Hist. Ser. 2, vol. vii. p. 14.

by the Marchioness of Hastings, Mr. Searles Wood, and Mr. Falconer, and all the species appear to be peculiar and distinct from those in the Bembridge and Hempstead series,—a fact to which attention was called by Lady Hastings some years ago, and before the differences as to the age and position of the strata themselves had been suspected.

The lower beds of the Headon series rest upon sands known as Headon Hill sands, which are the equivalents of the Upper Bagshot beds. No fossils had hitherto been observed in these beds in the Isle of Wight. In reality, however, at Whitecliff Bay they are highly fossiliferous, containing abundant impressions of marine shells, apparently of Barton species. The shells themselves have wholly disappeared, and owing to the loose and friable condition of the sands, the specimens are quite untransportable.

These sands rest upon the Barton clays, or highest portion of the Middle Bagshot group.*

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d'. Fossils of the Headon Fluvio-marine Series.

Murex sexdentatus. Sow. Colwell Bay.

Buccinum desertum. Brand. Colwell Bay.
„ labiatum. Sow. Colwell Bay.

Ancillaria subulata. Lam. [A. buccinoides. Lam.] Headon. Colwell Bay. Bracklesham. Barton.

Voluta depauperata. Sow. Barton.
„ spinosa. Linn. Bracklesham. Barton.
(Not V. spinosa, according to Edwards, l. c. p. 164.)

Marginella pusilla. Edwards, p. 143. Tab. xviii. f. 6, a-c.
„ vittata. Edwards, p. 144. Tab. xvii. f. 7, a-c.

Pleurotoma Headonensis. Edwards. Pl. v. f. 4. Morris App. p. 155.
„ innexa. Solander sp. Pl. v. f. 5. do. p. 154.
„ plebeia. Sow. Pl. v. f. 1. do. p. 154.
„ „ var. α. β. Forbes. Pl. v. f. 2.

Borsonia sulcata. Edw. Pl. v. f. 3. App. p. 154.

Cancellaria muricata. Wood. Colwell Bay.
„ elongata. Wood. do.

Natica similis. Sow. [N. epiglottina. Lam.]. Bracklesham. Barton.
„ labellata. Lam.
„ glaucinoides. Sow. Bognor. Bracklesham. Barton.
„ depressa. Sow. Bracklesham.

Cerithium plicatum. Lam. Headon.
„ mutabile. Desh. var. Pl. iv. f. 6.

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* For further details see notes by Mr. Bristow, p. 131, and Pl. 9 and 10.

[Potamides] acutum. Sow. Headon.
„ pseudo-cinctum, D'Orb. Headon. Hordwell. Pl. iv. f. 7.
„ concavus. Sow. do. do.
„ margaritaceum. Sow. non Brong. Headon.
„ duplex. Sow. Headon.
„ ventricosum. Sow. Headon. Pl. iv. f. 2.
„ trizonatum. Morris. Pl. iv. f. 8.

Melania costataz. Sow. Headon. Hordwell.
„ fasciata. Sow. Headon.
„ minima. Sow.
„ muricata. Wood.
„ peracuminata. Charlesworth. Pl. iv. f. 5.

Melanopsis brevis. Sow. U. C. t. 153. f. 2. Morris. App. p. 156.
„ fusiformis. Sow. Headon. Hordwell.
„ sub-fusiformis. Morris. Pl. vi. f. 2, 3. Morris App. p. 155.
„ carinata. Sow. Pl. vi. f. 8, 9. do. p. 156.
„ subcarinata. Morris. Pl. vi. f. 5, 6. do. p. 156.
„ subulata. Sow. Pl. vi. f. 1. do. p. 155.

Nematura parvula, Desh. ? Pl. iv. f. 4.

Hydrobia polita. Edw. [Bulimus.]

Actæon.

Paludina concinna. Sow. Headon. Colwell. Hordwell.
„ lenta. Brand. do.

Nerita aperta. Sow. Colwell Bay.

Neritina concava. Sow. Headon Hill.

Helix Headonensis. Edw. l.c. t. 11, f. 5. Headon.
„ labyrinthica, Say. ib. t. 10, f. 7. Headon. Hordwell.

Succinea imperspicua. S. Wood. Edw. p. 81. t. xi. f. 3. Hordwell.
Limnæa angusta. Edw. p. 95, t. xiv. f. 6. Also Hordwell.
„ arenularia. Brand. Edw. p. 95, t. xiv. f. 13. Hordwell. Beauchamp.
„ columellaris. Sow. Headon. Hordwell. Aurillac.
„ cincta. Edw. p. 94, t. xiv. f. 5. Headon.
„ caudata. Edw. p. 83, pl. xii. f. 2, a–c. Headon. Hordwell.
„ convexa. Edw. p. 92. t. xiii. f. 7. Headon.
„ costellata. Edw. p. 93, t. xiii. f. 10. Headon. Hordwell.
„ fabula. Brong. Edw. p. 94, t. xiv. f. 10. Hordwell. Cantal. Kleyn Spauwen.
„ fusiformis. Sow. Headon. Colwell Bay. Hordwell. Aurillac.
„ gibbosula. Edw. t. xiv. f. 8. Headon.
„ longiscata. Brong. Headon. Colwell Bay. Aurillac.
„ minima. Sow. Headon.
„ mixta. Edw. t. xiii. f. 5. Headon.
„ ovum. Brong. Edw. t. xiv. f. 12. Headon. Pierrelaie.
„ pyramidalis. Desh. Edw. t. xviii. f. 2. Headon.
„ recta. Edw. t. xiv. f. 7. Headon.
„ sublata. Edw. t. xiv. f. 4. do.
„ subquadrata. Edw. t. xiii. f. 1. do.
„ sulcata. Edw. t. xiv. f. 4. Headon. Hordwell.
„ tenuis. Edw. t. xiv. f. 11. do.
„ tumida. Edw. t. xiii. f. 6. do.

Planorbis elegans. Edw. p. 107, pl. xv. f. 12.
„ euomphalus. Sow. Hordwell.
„ lens. Brong. Hordwell. Limagne.
„ obtusus. Sow. Headon. Hordwell.
„ rotundatus. Brand. Brongn. Hordwell. Versailles. Fontainebleau. Aurillac. Cantal.
„ platystoma. S. Wood. Edw. p. 103, pl. xv. f. 2. Hordwell. Sconce.

Ostrea flabellula. Lam.
„ gryphina. Desh.

Pecten.

Mytilus affinis. Sow. Colwell Bay, with Mya angustata, and Potamides ventricosus.

Dreissena Brardii. Fauj. Headon and Hordwell,

Nucula deltoidea. Lam.
„ Headonensis. Forbes. [N. similis. Wood.] P. vi. f. 12.

Unio Solandri. Sow.

Cyclas.

Cyrena arenaria. Forbes. MSS.
„ cycladiformis. Desh. Headon. Barton.
„ deperdita. Lam. Pl. vi. f. 11.
„ gibbosula. Morris. Pl. vi. f. 13.
„ obovata. Sow. Headon. Colwell Bay. Barton.
„ Wrightii. Forbes. [an C. pulchra. Sow.]

Cytherea incrassata. Desh. Headon. Colwell. Hants.

Tellina ambigua. Sow. M.C. Colwell Bay.

Psammobia compressa. Sow.
„ solida. Sow. Headon Hill.

Potamomya gregarea. Sow. M.C. Headon Hill and Colwell Bay, top of U. F. W.
„ plana. Sow. M.C. Headon Hill. Hordwell.

Mya angustata. Sow. M.C. Colwell Bay.

Panopæa corrugata. Sow. Colwell Bay.

Corbula cuspidata. Sow. M.C. Colwell Bay.
„ nitida. Sow. M.C. with the above, below Upper F. W.

Pollicipes reflexus. Sow. M.C. Darwin. Fos. Lep. Colwell Bay.

Balanus unguiformis. Sow. Darwin. Colwell Bay. Headon.

Serpula tenuis. Sow.
„ corrugata. Sow.

Teeth of Squalus.

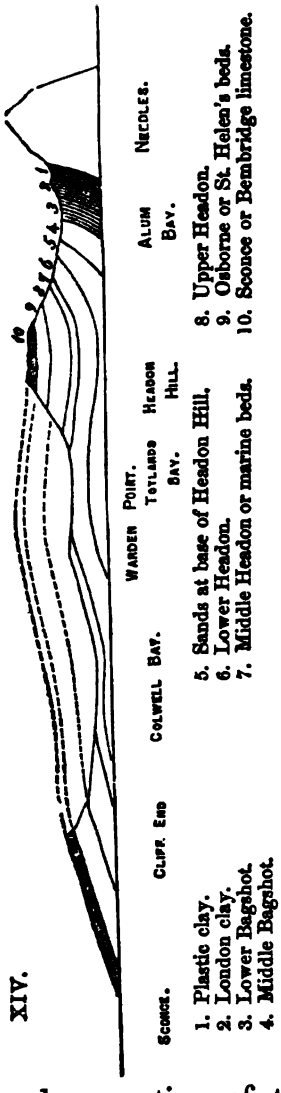
Teeth of Myliobatis.

Carpolithes ovulum. Brong. (Rhytidosporum. Hooker, 1855.)
„ thalictroides. Brong. (C. Websteri. id.) Folliculites, Zenker

Chara Wrightii. Forbes.

d". *Foreign Equivalents of the Headon Hill and Osborne Series.*

There have been very conflicting opinions, as in part will already have been seen, respecting the division of the tertiary strata of the Paris basin and of Belgium, which may be the equivalent of the series at Headon Hill.



XIV.

It was originally suggested by Mr. Webster that they represented the whole series of the tertiary strata of the Paris basin above the calcaire grossier. M. D'Archiac (1849) regarded them as representing his fifth group, —that of the calcaire silicieux only, and as possibly represented by the Sables de Diest in Belgium.

M. Dumont (1851) identified them with his Tongrien system of Belgium, the Limburg series of Sir Charles Lyell.

M. Hébert (1852) considered that the bed with *Venus incrassata* of Colwell Bay was higher in the series than any part of the Headon Hill strata, and was the representative of the Grès de Fontainebleau and of the Limburg beds. He compared the Hordwell freshwater deposits with those of Montmartre, and the Barton marine beds (Middle Bagshot) with the Grès de Beauchamp. A statement of my own observations will best serve to show the points of difference between them and those of previous investigators.

The section at Headon Hill includes only a portion of the fluvio-marine strata of the Isle of Wight, and the greater part of the island north of the

chalk range is occupied by beds higher in geological position than any seen in Headon Hill.

The section at Whitecliff Bay includes not only all the fluvio-marine series of Headon Hill, but also a thickness of nearly 100 feet of strata higher than any seen in that locality.

The Colwell Bay section is composed *entirely* of beds present in Headon Hill. [Woodcut XIV.]

Hempstead Hill, east of Yarmouth, presents a thickness of from one to two hundred feet of beds, which are higher than those which conclude the series at Whitecliff Bay.

The limestones of Binsted, Seafield, Calbourn, and Sconce belong to the same bed with the Bembridge limestone, which is not the equivalent of any conspicuous limestone on Headon Hill, but is there represented by a calcareous marl, mostly concealed by the gravel that caps the hill.

Palæontologically the Headon Hill beds (exclusive of this capping) form a group distinct from the Bembridge limestone and its associated marls.

Arguing, therefore, both from order of superposition and fossil contents, I am induced to consider that the series holds the following relations to the Paris and Belgian groups :

1st. That the sands at the base of Headon Hill, and the freshwater beds lying between them, and the "Upper marine" and "Upper freshwater formations" are, as maintained by Mr. Prestwich, the equivalents of the upper part of the calcaire grossier of the French basin.

2d. That the Osborne or St. Helen's series represents the "Grès moyen" of the same area.

Note upon the Tables of Fossils.

[There are two sets of results to be derived from the study of the foregoing synoptical lists, and which may be separately tabulated. It has been seen that the sequence in the fluvio-marine series of the Isle of Wight is such as to present no break throughout from the Headon beds to those of Hempstead inclusive. The whole was accumulated beneath an

area which was continuously subaqueous; which experienced slow depression just as the sedimentary beds were deposited over it, and which, from such changes, was at one time in the condition of a pure freshwater lake, at another, of a brackish-water lagoon. Such a series of conditions as these would render the introduction of any broad divisional line, such as should limit distinct geological formations (an eocene and a miocene for instance) to be wholly inadmissable. This is in strict accordance with the teachings of pure physical geology.

It might possibly have happened during the lapse of those vast periods of time, which are implied by the thick accumulations of purely fresh-water strata which parts of our series present, that a complete change might have taken place in the fauna of the neighbouring seas, and that two sets of fluvio-marine deposits, so separated, should present indications of very distinct marine faunas, yet without any corresponding physical break. Such an order of change will be recorded in the sequel with respect to the Purbeck and Wealden groups. In the tertiary series of the Isle of Wight, the various groups into which it has been subdivided are purely conventional,—such as are convenient ones for description; and although they may indicate a progressive change in time, as to their contents, yet the whole will be seen to be connected by a set of common forms, each influx of the waters of the adjacent sea, and which brought about fluvio-marine conditions where lacustrine ones had obtained before, brought back a recurrence of those forms which are referable to the "Barton group" on the marine tertiary scale. This is exhibited in Table (p. 92); and if our comparisons of the several parts of the Isle of Wight series with those of the tertiary deposits of France and Belgium be correct, it will be seen that we have here the clue to the difficulty which has been felt by continental geologists as to the upper limits of the older tertiary series.]

LINKS between the several Series in England.

A. Between Hempstead and Bembridge series.

Cyrena semistriata
Melania muricata.
„ fasciata.
Paludina lenta.

B. Between Bembridge and St. Helen's series.

Cyrena obovata.
Paludina globuloides and lenta.
Melanopsis carinata.
Melania muricata and fasciata.
Lymnæa longiscata.
Planorbis obtusus and rotundatus.

C. Between St. Helen's and Headon series.

Cyrena obovata.
Potamomya plana.
Melanopsis carinata.
Paludina lenta.
Melania muricata and fasciata.
Lymnæa longiscata.
Planorbis euomphalus, rotundatus, obtusus.

D. Between Headon and Barton series.

Ostrea flabellula.
Natica depressa.
Buccinum desertum.
Calyptræa trochiformis.

Between A. and D.

Melania muricata and fasciata.
Paludina lenta.

Between B., C., and D.

Cyrena obovata.
Limnæa longiscata.
Melanopsis carinata.

Between B and D.

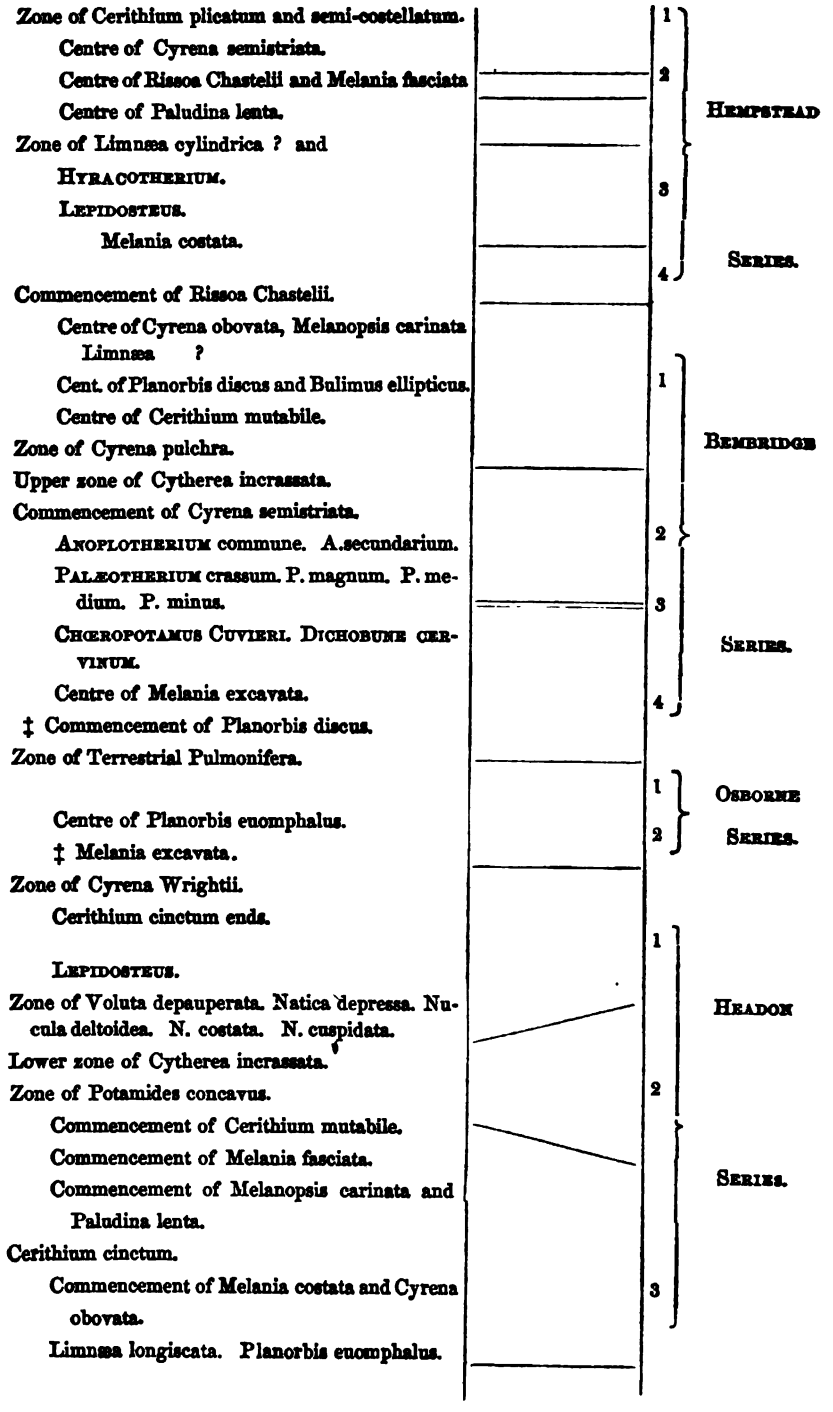
Helix labyrinthica.

Corbula pisum, C. globosa, C. striata, C. revoluta, Ostrea flabellula, Fusus bulbiformis, in all beds below the Headon series.

[The second result, exhibited in Table (p. 94) has reference to that change in time which is to be observed in the sequence of organic forms. This Table is as limited in its use and bearings as the former one was generally significant and suggestive. It brings out what is perhaps nothing more than the result of purely local conditions, and as such can only have a local use. The object is to represent that certain specific forms were introduced or made their appearance on the scale of the fluvio-marine series of the Isle of Wight at a definite stage, that each acquired numerical importance, and finally disappeared. It must not be supposed that any particular form, whose career can be so traced, had its origin and extinction within such limits; or that its maximum diffusion even in these latitudes corresponded necessarily with the place marked as its zone or centre here. *Bulimus ellipticus*, with a restricted range in the Isle of Wight series, occurs in the London clay of the London basin, and as low in the deposits of the Paris basin.

With respect to the higher vertebrate forms recorded in the Table, we must consider their occurrence in association with the greatest number of terrestrial pulmonifera, as indicating that at that time the area had made its nearest approach to terrestrial conditions. The higher forms, as well as the lower, spread into our area, according as in the progress of change it afforded conditions favourable for their establishment.]

TABLE showing the DISTRIBUTION of PRINCIPAL SPECIES.



General view of the Foreign Equivalents of the Upper Tertiary Series.

The onward progress of geology demands reiterated revisals of lists of organic remains, as well as renewed examinations of the districts in which they have been found. It is unsafe in most instances to depend on the lists given with papers dating some 20 years ago or fewer; and a careful estimate of the acquirements of the cataloguer, as well as of the value of the materials which he had at hand for comparison, requires to be made before we can venture to mingle published data of some years standing with more recent observations as grounds for generalization. This remark especially applies to all that concerns freshwater and fluvio-marine deposits. Hence, the suggestions I have to offer in this portion of my essay must be received with caution, and rather as presented with a view to future inquiry than as conclusions arrived at on ample grounds.

Spanish Peninsula.

If we accept the scanty, but at the same time important lists of freshwater fossils found by Colonel Silvertop in the deposits of the basins of Buza, Alhama, and Teruel, in Spain*, and which lists were drawn up by Mr. Sowerby, who had certainly authentic means of comparison at hand, we must recognize a relation between the beds in question and the freshwater ones of the Headon series. At the same time, it is not impossible that these Spanish freshwater beds may belong to the Upper Eocene period (Bembridge and Hempstead series), and that there may be a definite gap in time between the epoch of their formation and that of the underlying marine beds, resting upon Nummulite limestone. The latter rock is represented by Colonel Silvertop as unconformable to the freshwater beds in the basin of Teruel, in Arragon, and in which strata *Planorbis rotundatus* and *Limnæa pyramidalis* are said to occur.

* Ed. New. Phil. Journ. Jan. 1831.

France. South-Western Area.

[In spite of the researches of many observers, the relations of the various deposits of the tertiary basin of the Garonne and the Dordogne, continued to be involved in considerable obscurity till the appearance of the able memoir of M. Delbos.*

From the numerous sections the author has represented and described, it appears that the assemblage of fresh-water sands, clays, and limestones, known as the mollasse of Fronsadais, Bergerac, and Paullac, and equivalent beds in other places, follow next above the orbitolite limestone of Blaye and Paullac. This forms the lower freshwater series of the south-west of France. The molasse is of great thickness, and contains, principally in the lower portion, the remains of the Cuvierian Palæotheres (*P. magnum*, *P. crassum*, *P. minus*). The Orbitolite limestone is characterized by *Cerithium giganteum*, *Terebellum convolutum*, *Clavagella coronata*, *Orbitolites complanata*, and other forms, which make their first appearance in the English Nummulitic series at the level of the Bracklesham and Barton deposits.

The freshwater mollasse is surmounted by a continuation of deposits of like origin, and which are separable from it on considerations of mineral composition alone. These consist of compact marly limestones, with subordinate masses of siliceous mill-stone. *Limnæa longiscata*, *Planorbis rotundatus*, are the common shells of this group.

The mollasse and limestone series taken together represent a vast period of time, during which the waters of the sea were excluded from the basin of the Garonne, and when that area became converted into a purely freshwater lake; after this it was again sea. This interval of lacustrine conditions includes the Palæotherian period, a consideration, which, judging from the limited range these forms have in the Paris series as well as in our own, may perhaps serve

* Memoires de la Soc. Géol. de France, 2d ser., vol. ii., p. 241.

as a safe guide in co-ordinating the lower tertiary strata of the south-west of France with those of the valley of the Seine, and also with our own.

A like general order of sequence is to be observed in the south-west of France and in the Isle of Wight area, the molasse series being represented by that succession of freshwater conditions which, commencing with the Headon series, ranges on up to the Bembridge group inclusive. Still there are considerations which arise out of the very conditions under which the two series of the south-west of France and that of England were formed, and also from the circumstance that the distance of the two areas is great, and was always distinct, as it would render it most hazardous to infer any close synchronism between any component parts of the two series, from the mere fact of such like general sequence.

The circumstances which determine whether any particular area shall be occupied by the waters of a lake, a lagoon, or of a sea, are so entirely connected with purely local physical accidents or features of form and relative elevation, as to preclude the supposition, that because the conditions were like, the resulting deposits must be alike as to age. Again, the study of the marine Nummulitic fauna, considered stratigraphically, suggests that the direction of marine colonization was by the extension northwards of forms which had long previously appeared and become established in the Mediterranean area. This process of diffusion is necessarily slow. At the same time, the physical changes which led to the formation of marine basins within our area during the older tertiary period, were apparently those of slow and progressive depression, and that from south to north; any definite assemblage therefore of specific forms, such as geologists designate when they speak of a "Bracklesham or a Barton fauna," whilst it may be the geological equivalent of a like assemblage elsewhere (as of the orbitolite limestones), may likewise be separable from it by a vast interval of time.

The great freshwater lake which for a part of the older tertiary period occupied the present basin of the Garonne,

was fed by streams which descended from the central crystalline region of France; the lácustrine deposits of the south-west of France are thus connected with those of the Cantal as the immediate result of the physical geography of the region at that period. These lacustrine deposits of the valley of the Garonne are thickest on the side of this old land surface.

The marine beds which have been alluded to as overlying this great lacustrine group, are those which are known as the "calcaires à Astéries," from the numerous ossicles of *Asterias lævis* they contain. This marine series has been subdivided by Mr. Delbos somewhat differently to what it was in his original memoir; and he is now disposed to place a part in the middle tertiary division (Miocene) and part in the lower (Eocene), and to make it the passage of the one to the other. The first view, however was perhaps the most natural, for a common fauna runs through the series, and it moreover seems to be most in conformity with that succession which the Isle of Wight series presents in that part with which the comparison must obviously be made.

The lowest part of the marine group here in question consists of scattered beds of sand, with a peculiar large oyster (*O. longirostris*). This species, which at the commencement of the marine conditions formed large beds or colonies over this area, extends upwards into the great mass of the Calcaire à Astéries, together with several other common species. The compact limestone series is not separable from the oyster-bearing beds beneath on any admissible considerations. The *Ostrea callifera* which, as has been seen, has served to place our Hempstead series in comparison with that of Fontainebleau, is but a variety of *O. longirostris*, and marks a definite stage in the higher portion of the Eocene group, both here as also in the Paris basin. If the divisional line between two great distinct groups, such as a lower and middle tertiary may be supposed to be, can be drawn at any part of this marine series, it most certainly cannot be where M. Delbos is disposed to place it, namely, between the beds with *O. longirostris* and the Astéries limestone.

It is above this last that those deposits occur which from the abundance of cetacean remains they contain are known as the "Molasse ossifère." It is a marine formation, and, like that next subjacent, abounds in remarkable forms of Echinoderms, which never ranged northwards into our area.

There are certain other bands of well-marked fossils which seem to be so widely extended as to indicate definite horizons; of these, perhaps the most constant is the zone of *Cerithium plicatum*, well marked among the tertiaries of France, Belgium, and Germany, and equally so in the Isle of Wight.

In the south-west of France, as in the basin of the Adour, the place of this zone is in the "faluns jaunes" which overlie the Mollasse ossifère; and it is on such considerations that in the tabular view of equivalents, the column of the south-west basins of France has been so arranged that this part of the series is made to correspond to the middle part of the Hempstead.

The relation of this zone of the *Cerithium plicatum* to the marine beds with *Pecten latissimus* of the south-east of France, may also enable us to fix the position of the Maltese and other Mediterranean tertiary formations, hitherto classed as miocene. There is evidently no break in this part of the series of tertiary depositions, and it would be harsh and forced to place one portion in the eocene and another in the miocene, as has been done by continental geologists. In the Isle of Wight we have the true clue to their relations clearly exhibited in unmistakeable and perfect sections, the importance of which clue in its bearing on continental geology may be estimated very highly.]

The following table of British and Foreign Equivalents is here given as it was prepared by the late Professor Ed. Forbes. It has been compiled with great care, and embodies the views of the several leading systematic geologists of the present day who have treated of the lower tertiary formations.

The first column contains M. D'Archiac's grouping of the whole of the tertiary series of the Paris basin, according to natural subdivisions, based on stratigraphical as well as palœontological considerations. The subsequent columns represent the views of the several authors whose names they bear,—D'Archiac, Lyell, Dumont, Prestwich,—as to the synchronous or equivalent portions of the same lower tertiary series, as presented in the Isle of Wight and in Belgium.

The column headed "Geological Survey" gives Professor Forbes' own views, based on considerations which have been fully set forth in the preceding pages.

It must therefore be understood that each column has reference only to the first or French table, and that the use and value of the table as a whole consists in this,—that it presents at a glance what would have required a great amount of labour and attention if given narratively.

Besides this, the Author of the Memoir would doubtless have compiled another table representing the wider geographical equivalents for the whole of the nummulitic or lower tertiary area, to have illustrated the latter unfinished chapters of his work: and as some of these views are given in a table appended to the Memoir* communicated to the Geological Society, they are here reproduced.

		Mayence.	Vienna.	S. W. of France.	Mediterranean.
		°	°	?	
Hempstead series.	Upper or Corbula beds.				
	Middle.	Upper brown coal and Cerithium-kalk.	Lower division of the Vienna tertiaries.	Faluns jaunes of Dax.	
				Molasse ossifère.	Maltese beds; also in Corsica, Greece, Crete, Cerigo, S. of Spain and Portugal, Azores, and N. of Africa.
	Lower.	Marine beds.		Calcaire à Astéries.	
Bembridge Series.	Upper or Bembridge marls.			Molasse of Fronsadais and associated beds.	
	Middle or oyster beds.				
	Lower or Bembridge limestone.				

* Journ. Geol. Soc., vol. ix. p. 270.

			BELGIUM.		
	GICAL SURVEY.		D'ARCHIAC.	LYELL.	DUMONT.
ELE AC.					
ME.	1. Calcaire à Hél			Upper Limbourg or Rupelmonde Clay	Rupelien
	2. Argile et Meu	(Corbula)			
Grès Supe	1. Grès de Fonta	arine, Upper			
	2. Sables et bancs	Middle			
	3. Marnes marin	arine, Lower			
		Hempstead Series.			
SE.	1. Argile et Meu	and F. W. Upper		Middle Limburg or Fluvio-marine	Upper Tongrien
Calcaire ou Calcaire Moyen	2. Marnes, Calca disséminée	Middle	Sables de Diest? These are Pliocene for Dumont and = Crag		
	3. Marnes verte			Lower Limburg	Lower Tongrien
	4. Gypse et Marn	rial Lower			
	5. Marnes et Cal				
		Bembridge Series			
e, Grès Moyens	1. Calcaire Mari	e Series			
	2. Grès [de Bess	Upper	Sables et coquilles du Limbourg	Laecken beds or Upper Nummulitic [N. variolaris]	Laeckenien
	3. Sables	Middle			
		Lower			
		Headon Series			
upe, Calcaire	1. Marnes			Brussels beds or Middle Nummulitic [N. lævigatus]	Bruxellien
	2. Calcaire Gross	Hill Sands	Groupe Calcareo-sableux		Panisilien?
	3. Calcaire Gross	per Bagshot Clay		Lower Nummulitic	
	4. Calcaire Gross	sham Beds		[N. planulatus]	
		Middle Bagshot			
upe, Sables urs	1. Glaises et Sab		Groupe Quartzo-sableux	[London Clay * wanting in France]	Ypresien Sup.
	2. Lits coquillier				Ypresien Inf.
	3. Sables divers			Plastic clay and sand	
	4. Grès Pouding				Landenien Sup
	5. Glaises sableu			Glauconite et Tufau de Lincent	Landenien Inf.
	tres, Lignite				
	6. Glauconie inf.		Calc. Lac. Inf. & Rilly Beds	Marls & Glauconite of Heers.	Heersien

ix., p. 230.

NOTES BY H. W. BRISTOW, F.G.S.*

Geological Survey of Great Britain.

Gravel of Freshwater Gate, page 2, (II. 1.)

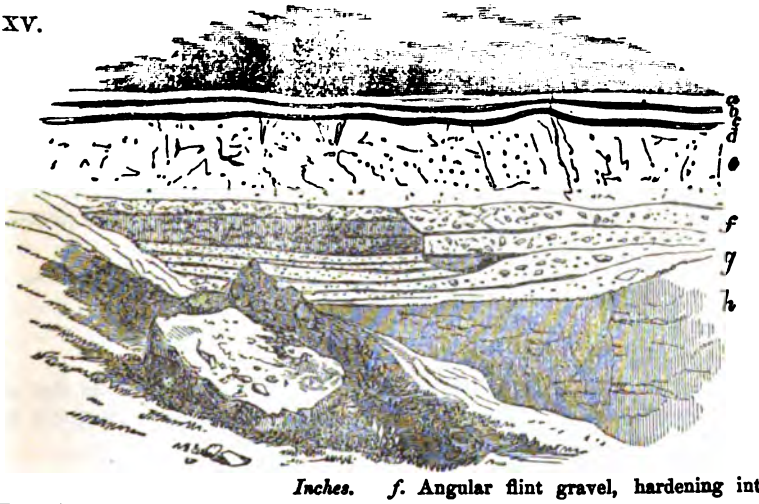
These gravel beds are seen on the shore filling the hollow in the chalk cliffs between the fort and the point where there is a divergence in the track ascending Afton Down.

Between the eastern end of the fort and the Albion Hotel the gravel is composed of angular flints, interstratified in places with sand, and resting on a surface of reconstructed chalk mixed with unaltered flints and sandy loam. The flints are, for the most part, reduced to a small size, and the sand frequently passes into sandy loam, the whole bearing a strong resemblance to the high level gravel of the Stour Valley noticed at page 11. On the eastern side of the hollow the flints are less numerous, and the gravel is more sandy and loamy than on the west. Elephants' teeth have been dug up behind the Albion Hotel. The greatest thickness does not appear to exceed 18 feet.

Hazel-nut Sands, &c. of South Coast, p. 7, (II. 4.)

The appearances mentioned in the extract from Sir H. Englefield's work, quoted in the text, are no longer visible. The gravel beds are best

XV.



	Inches.		
a. Ferruginous loam	6	*f.* Angular flint gravel, hardening into conglomerate.	
b. Black clay	6	*g.* Coarse sand, with fragments of fine sandstone, nuts, twigs, branches, &c.	
c. Pale ferruginous clay	6		
d. Black carbonaceous clay	6	*h.* Red mottled clay of the Wealden.	

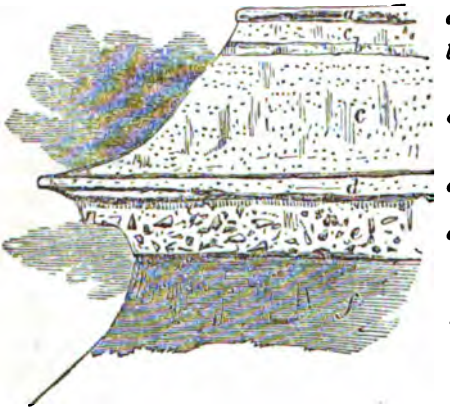
* Many of the materials for the accompanying Notes were obtained in 1852, when the geological survey of the island was commenced.

The greater portion of them, however, and nearly all the sectional details, are the result of a visit to the island in the spring of the present year, in company with Professor

seen at present in a small chine (west of Brook Point), of the eastern side of which Fig. XV. is a sketch made in June 1856. The upper two feet consist of black peaty clay and ferruginous pale clay, overlying ferruginous loam, which rests upon angular flint gravel, sometimes hardening into conglomerate, beneath which is a coarse sand enclosing fragments of fine sandstone. This sand, based upon the red mottled clay of the Wealden, contains numerous nuts, (called Noah's nuts by the people of the island,) and the remains of beetles mixed with matted fragments of twigs and branches of trees. The latter, which are sometimes coated with phosphate of iron, retain their original shape and general appearance, being saturated with water which, on evaporation, leaves a light shrivelled substance behind. The largest pieces do not exceed two to three inches in diameter. The trunks of trees on the shore at Brook Point are not of the same date with the vegetable remains above noticed, but they are of much larger dimensions, and are completely mineralized by silica and pyrites, by which they have been converted into a hard black stone susceptible of polish.

In making a road at Weston Chine some years ago nuts "with their husks on" were found beneath the gravel under conditions similar to those just described.

XVI.



a. Soil, 2 feet.

b. Iron band.

c. c[1]. Sand, 7 feet.

d. Hard sandstone, 9 inches.

e. Large angular flint gravel, containing iron, clay, and quartz pebbles.

f. Black shales of the Wealden.

Woodcut XVI., from a sketch taken on the west side of a chine in Compton Bay, shows the mode of occurrence of the gravel which overlies the blue or uppermost beds of the Wealden there.

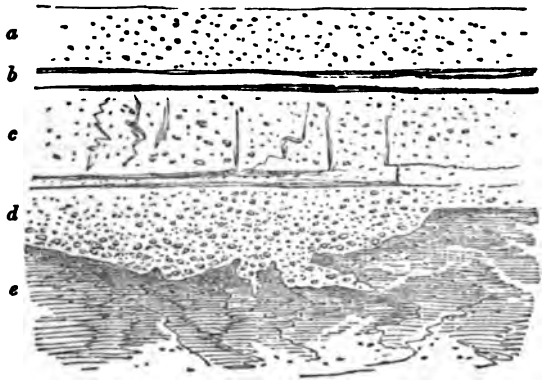
Ramsay, Local Director of the Geological Survey of Great Britain, and Professor Morris, of University College, to both of whom I am under great obligations for their valuable aid, in my endeavour to render more complete the Memoir which had been left only partially finished at the death of my late lamented friend and colleague.

To Professor Morris my thanks are especially due, for the unvarying kindness with which his extensive palæontological acquirements, and his intimate knowledge of fossil and recent forms, were, at all times, brought to bear on the subject, both in the field and out of it. H. W. B.

Lacustrine Beds of Tollands Bay, p. 8, (II. 5.)

The lacustrine beds of Tollands Bay have been rendered more favourable for examination since Professor Forbes' description was written, the upper portion of the cliff occupied by them having recently been cut back throughout their entire length of nearly 350 yards.

XVII.



Lacustrine Beds.

a. Sandy brown ferruginous loam.
b. Brown clay and perished shells.
c. Fine tufa.
d. Coarser tufa.
e. Potamomya sands of the Upper Headon beds.

This deposit is very variable, but its general character is well described by Prof. Forbes. On the top, Fig. XVII., is an unequal thickness of brown loam containing a few scattered angular flints, under which is a layer of brown clay and perished shells, resting upon four or five feet of calcareous tufa (with a few black lines, the result of decayed vegetable matter) which sometimes equals a limnæan limestone in hardness.

The tufa is finest on the top, and it becomes coarser by degrees towards the lower part, where it is full of round calcareous concretions of various sizes, and what appear to be twigs and stems of plants, which, having fallen into water highly charged with carbonate of lime, have been enveloped by the latter. These concentric concretions are also larger at the bottom and decrease in size upwards, the whole resting on an uneven surface of the Eocene Potamomya sands which underlie the limnæan limestone of Tollands Bay. Occasionally there is a layer of small angular flints between the tufa and the sands.

Throughout, there is an appearance of the deposit in question having been quietly and gradually formed in a hollow beneath the waters of a small lake or pond into which flowed the surface drainage of the surrounding higher grounds. One portion only is now left of the bed of this lake, which probably ceased to exist, when, by the wearing back of the land, the cliffs encroached upon its western margin, and drained it of the water. The limits of that portion of its bed which still remains can be

traced by means of the superior luxuriance of the vegetation it supports. The limestone formed its banks on the east side up to the commencement of the lane, and thence on the south to its present termination on the edge of the cliff.

Helix nemoralis, H. rotundata, Cyclostoma elegans, with occasional *Bulimus lubricus,* and *Pupa muscorum,* are the most abundant land shells, and occur throughout; while in the loam are *Succinea* and *Limnæa,* and in the lower part a small *Planorbis* and fragments of *Unio.*

Subaërial Beds of St. Catherine's Down.

On the summit of the cliff, between Rocken End and St. Catherine's Down, beds occur of similar origin partly to those of Tollands Bay, just described.

In the former locality, however, the beds are formed of a hard deposit of calcareous mud, derived apparently from chalk, which becomes gradually more indurated and mud-like, and of a darker colour towards the bottom.

It differs from the analogous beds in Tollands Bay, in containing neither the remains of freshwater Mollusca or of Cyclostoma elegans. It is, however, full of *Helix aperta, H. aspersa, H. nemoralis, H. ericetorum, H. virgata, H. rotundata, Bulimus lubricus,* &c.; and small fragments of chalk, upper green sandstone (with an occasional small fossil) and chert are sparingly distributed through it. The top is free from gravel.

The thickness of the bed does not exceed 9 feet. It may readily be distinguished from the chalk by its darker colour, and by its forming a vertical wall-like cliff, while the chalk and chloritic marl, upon which it reposes, are of a whiter colour, and slope gently from its base to the top of the upper green sand on the edge of the cliff.

SECTION No. I.

Hempstead Strata.

Measured in the Cliff at the Western Outcrop of the Corbula Beds.

Descending.

	Ft.	In.
Rounded and angular gravel (high level gravel) - 4 to	8	0
Corbula Beds (1).		
1. Greenish clay, with occasional layers of compact nodular clay ironstones (sometimes 9 inches in diameter), with a ferruginous sandy coating, and containing fossils, Corbula pisum, C. Vectensis, Cypridæ - - - -	5	0
2. Shelly band of broken Cyrena semistriata (often of large size), with occasional patches of greenish and ferruginous sand. Thickness variable, from 4 in. to 1 ft. - - -	0	6

	Ft.	In.
3. Stiff brown clay, with scattered nodules of clay ironstone (a 4 inch band of which, occasionally dying out, occurs at 3 feet). Corbula Vectensis, C. pisum, Voluta Rathieri, and other univalves, Cyrena semistriata, Cerithium plicatum, Crustacean claw, Cypridæ, &c. - - - -	4	0
Total thickness - - -	9	6

Upper Freshwater and Estuary Marls (2).

4. Dark laminated shaly clay, brown in the upper part. No fossils. Thickness variable, 1 ft. 6 in. to - -	2	0
5. Cerithium plicatum bed, with numerous Cyrena semistriata, Melania, fragments of Unio. Thickness variable -	0	6
6. Laminated dark greenish and bituminous clay, with bands of marly sands at 3 inches from the top, containing occasional fragments of shells (obtuse Planorbis in abundance) and patches of Unio at 1 ft. 6 in. Cyrena semistriata, occasional Cerithium plicatum (probably washed out of the sand below), lignite, Cypridiform shells at the bottom part - - - - -	2	9
7. Grey ferruginous shelly sands, with Cerithium plicatum, C. elegans, Cyrena semistriata (generally broken), Melania (like fasciata), Melania (smooth species). At the bottom, Rissoa Chastelii in great abundance, Corbula Vectensis, and Melania - - - - - -	1	0
8. Tenacious green clay, with scattered shells much broken. Paludina lenta, Limnæa ? - - - -	2	0
The surface of the bed undulating and irregular.		
9. Black carbonaceous clay, with fragments of shells - 3 in. to	0	6
10. Red and green variegated clays; Limnæa, Planorbis, Paludina in patches. At the base occurs a band, of more or less persistence, of red ferruginous clay, probably hardening in places into thin bands of ironstone (the Unio band found loose on the shore), Paludina, seeds, small bivalve ? Cyclas associated with the Unio - - - -	4	6
11. Light green and ferruginous clays, with patches of pale sand and bituminous layers containing Unio and Paludina (lenta ?) at the base - - - - -	10	0
12. A thin band of bituminous clay apparently of variable thickness and extent, filled with Carpolithes, Paludina, with many compressed shells, and also seeds in the lower part -	0	1
13. Green tenacious clay, having, at the spot examined, at its base, a thin bituminous band, with which is associated a band of lignite containing seeds; slightly above it are numerous compressed Unio, Melania fasciata, much selenite in small crystals - - - - -	2	6

Here the underlying beds are so concealed by underwood and covered with landslips and mud streams as to be nowhere visible, but probably the remaining portion of this group does not exceed 12 or 14 feet of unfossiliferous clays similar to those last described, making the entire thickness of the upper freshwater and estuary marls about 40 feet.

At another locality, about half a mile further east, where the section described by Professor Forbes was measured, the uppermost beds having been better preserved, are of greater thickness than in the preceding section, and contain a layer of oysters (Ostrea callifera), between which and the superficial gravel are three feet of clay. There, too, the Corbula clays in question contain Natica labellata and Voluta Rathieri, and the nodular ironstones are larger and more abundant and assume the character of true septaria.

With this difference, the details of the two sections are nearly identical down to the carbonaceous clay (No. 9), below which the brackish water clays, described by Professor Forbes as abounding with Cerithium plicatum, C. elegans, C. tuberculosum, Rissoa Chastelii, &c., were searched for in both localities without success. This discrepancy between the descriptions of the two sections has, most probably, originated in some confusion made in transcribing Professor Forbes' field notes, the result of which has been that the beds No. 7, 8, and 9 have by mistake been described twice over.

The only place besides those two already mentioned, where any part of the upper marls could be discovered, was in the first cliff below the west end of a strip of scrubby oaks skirting the hill. The details of the section there, as measured by Professors Ramsay and Morris, were as follows :—

SECTION No. II.

No.	Ft.	In.
1. Pale clay	0	4
2. Band, with Rissoa Chastelii	0	3
3. Pale clay, with	0	3
4. Band of Cyrena semistriata	0	1
5. Clay, with Cyrena semistriata, Cerithium plicatum, and Cypris-like shells (Cytheridea Mülleri)	1	0
6. Band of Cyrena semistriata, Cerithium plicatum, Melania fasciata, and numerous Rissoa Chastelii in patches, principally at the base	0	6
7. Blue clay	1	0
8. Stiff tenacious clay, dark in the upper part and greenish below; Cerithium plicatum and Panopæa in the upper part, Planorbis below.		

Here No. 6 is most likely identical with the upper part of No. 7 in Section No. I.

In no one locality can the remainder of the Hempstead strata be seen in an unbroken sequence; but by observations made at different places

where the beds may happen to be displayed, and by identifying a well-marked bed at one point with the same bed elsewhere, the section may be approximately continued to the *Black band* which, according to Professor Forbes, forms the base of the series, and thence downwards through the Bembridge marls to the Bembridge limestone of Hempstead ledge.

In general, nearly the whole of the middle marls are covered by land-slips and mud streams down to the *White band*. This bed presents a very marked appearance in the cliff and at its base along the shore, and by its means we are able to resume the section.

The following sections of the *White band* were measured by Professors Ramsay and Morris in a low cliff near the shore, between the eastern termination of the great founder and the west corner of the fir plantation.

SECTION No. III.

No.		Ft.	In.
1.	Clay, with ferruginous concretions	0	3
2.	Ferruginous shelly band	0	2
3.	Clay	0	3
4.	Cyrena bed; Rissoa, broken Cyrena	0	2
5.	Clay	0	1
6.	Cyrena bed; Rissoa at base	0	3
7.	Clay	0	2
W 8.	WHITE BAND; broken Cyrena semistriata, Cerithium, Unio, Paludina, Fish remains (vertebræ, teeth, and scales), Hyopotamus (jaw and teeth), seeds, and a few small black pebbles	0	9
9.	Greenish clay, unfossiliferous	1	0
10.	Stiff clay	1	0
11.	Clay, with four bands of Paludina	0	6
12.	Band of Unio and Paludina	0	1
13.	Clay, with ferruginous concretions; Cyrena obtusa, Cerithium and Melania at base	0	9

No. IV.

Section of the lower part of the middle freshwater and estuary marls of the WHITE BAND, measured in a low cliff on the shore, at the base of a great founder.

No.		Ft.	In.
1.	Rubble.		
2.	Small bands of clay, with apparently nodules of ironstone	0	4
3.	Band of crushed Cyrena 1 inch Shaley clay 1 inch Band of crushed Cyrena and Melania fasciata in great abundance, 1 inch	0	3

	Ft.	In.
4. Brown clay	0	1½
5. Ferruginous band; Melania fasciata, Cyrena, Paludina separated by a very thin layer (sometimes passing into it) from another similar layer	0	1½
6. Ferruginous band, containing the same shells; with Cerithium	0	2
7. Laminated clay, with bands of compressed Melania and Cyrena about	0	9
8. Greenish tenacious clay, with bands of Paludina and Fish remains	3	0
9. Ferruginous concretions, covering a layer of compressed Cyrena	0	2
10. Tenacious green clay; a layer of Melania (and bones of turtle) 1 inch from the bottom, with concretions of clay-ironstone	3	0
11. Thin layer of vegetable matter, with reed-like plants and long seeds (Folliculites), patches of Paludina	0	0½
12. Greenish sandy clay forming the shore, with large concretions; patches of shells, Paludina	3	0

Lower freshwater and estuary marls.

WHITE BAND	13. Verdigris-green clay, with two bands of Cyrena semistriata, more or less perfect; in the lower half of the bed (between which is a thin layer of ironstone with Panopæa Gibbsii?) Cerithium, Melania, Fish, and Folliculites in the lowest band of Cyrena; green clay	1	0

Further east, about 100 yards west of some stakes driven into the beach, where the *White band* comes to the base of the cliff, it contains occasional large white nodular concretions 10 inches thick and a yard long, while above it are two bands of clay ironstone, each one inch thick.

No. V.

Section measured eastward of the preceding section, where the WHITE BAND appears at the base of the cliff.

	Ft.	In.
Dark clay	2	0
Tenacious dark greenish clay; at two inches below the top of the bed are two 1-inch bands of tabular ironstone, containing Paludina, and separated by two inches of clay also with Paludina	1	0

		In.	In.	
W	Very shelly clay, with Cyrena, Melania, and Cerithium	3		
	Clay	$0\frac{1}{2}$		
	Shelly clay, as before	2		
	Clay with compressed Cyrena	1		
	Shelly bands, as before; sometimes separated by a thin layer of clay	3 to 4		
WHITE BAND.	Clay, with bands of Cyrena, Cerithium, and Melania	4	4	$1\frac{1}{2}$
	Green clay, mostly filled with broken Cyrena and Cerithium. The shells in this band are much blackened, and occasionally at the bottom are Panopæa in upright positions, partly sinking into the clay below, Melania fasciata, Cerithium Sedgwickii	2		
	Greenish clay about two feet from the shore, forming the base of the cliff, and containing bands of crushed Paludina		3	0

Further east of the place where the above section was measured, all the bands forming the *White band* unite, and are well seen in the cliff, forming a distinctly marked white line at its base, with about twelve feet of dark clay weathering brown above.

No. VI.

About S.E. of the buoy the following section was measured in a projecting point of the undercliff.

No.		Ft.	In.
1.	Laminated tenacious clay, with shelly bands, mostly made up of broken Cyrena	15	0
2.	Laminated clays, with Rissoa Chastelii and Cypridiæ	0	9
3.	Band of broken Cyrena	0	2
4.	Lenticular patches of white marl, containing fragments of lignite and disseminated vegetable matter, with reed-like stems	0	9
5.	Tenacious blue clay	0	3
6.	Fossil band; Melania muricata, Melanopsis; Cyrena or Cyclas, Hydrobia pupa, Cypris; Planorbis on surface of bed (P)	0	6
7.	Tenacious greenish clay, with layers of Paludina and seeds towards the middle	3	0
8.	Ochreous clay, passing into ironstone	1	0
9.	Stiff lead-coloured clays with several bands of Paludina towards the upper part; more sandy and ferruginous towards the base, where the beds sometimes become very finely laminated (B)	20	0

Probable position of the *Black band.*

No. VII.

Section measured further west, in the broken ground a few feet above the shore, about 29° E. of S. from the buoy on Hempstead Ledge.

		Ft.	In.
W	1. Traces of *White band* on the top of broken ground - -	0	0
	2. Ground not seen - - - - about	5	0
	3. Clay, weathering brown, with traces of Cyrena bands on the weathered surfaces - - - about	20	0
	4. Ferruginous band, with fragments of shells - -	0	1
	5. Laminated clays, unfossiliferous ? - - - -	4	0
	6. Clays, with laminæ of Cyrena semistriata - -	1	0
	7. Dark tenacious clay, with two bands of Cyrena, the upper containing numerous Hydrobia pupa and valves of Cyrena, often perfect and united at the hinge - - -	5	0
	8. Green clay, with Cypridæ - - -	0	4
P	9. Dark fossil-band, Planorbis on top of bed, Cypridæ throughout, associated with Melania muricata, M. fasciata, a smooth Melania, Melanopsis fusiformis, Limnæa, and Cyrena or Cyclas - - - - - -	0	5
	10. Clay, with band of Cypridæ and occasional Melania at the base - - - - -	0	6
	11. Clay - -	0	7
	12. Clay, with compressed Paludina and seed vessels - -	1	6

No. VIII.

Measured (by pacing) along the shore at low water, under Hempstead Hill.

	No.	Ft.	In.
P	1. Shelly band with Melania, Rissoa, Limnæa, and Planorbis on top of bed - - - - - -	0	6
	2. Green clays, with Paludina and seeds - - -	4	6
	3. White marl, with Paludina lenta - - -	0	3
	4. Green clays, with bands of Paludina lenta and Melanopsis carinata - - - - - -	18	0
B	5. *Black band*, with reed-like plants, and Unio and Paludina at base - - - - - -	1	9

In the three preceding sections, Nos. 6, 9, and 1 are most probably identical. Assuming such to be the case, the entire thickness of the whole of the lower freshwater and estuary marls, computed from Sections VII and VIII., would appear to be nearly 65 feet. Hence the total thickness

of the Hempstead strata, taking the Corbula beds at their greatest observed thickness, is as follows :—

		Feet.
1. Corbula beds		15
2. Upper	Freshwater and estuary marls	40
3. Middle		50
4. Lower		65
		170 feet.

The agricultural character of the Hempstead strata does not appear to be very good, the greater part of it being either waste land, or pasture and woodland.

SECTION No. IX.

Bembridge Limestone at Whitecliff Bay (1856).

Descending.

No.		Ft.	In.
1.	Hard white crumbly marl, with a few concretions and scattered shells, and becoming harder and more shelly for the lower 6 inches. Throws out water on the top. Planorbis discus, Limnæa in places. Passes gradually into the bed below No. 6. of Professor Forbes' section (: p. 53.)	2	6
2.	Hard, compact, very shelly limestone, sometimes forming two beds, with a harder darker-coloured parting between. Chara tuberculata and Ch. very abundant, Paludina orbicularis at two feet from the top, Limnæa, Planorbis discus, Planorbis	5	0
3.	Hard bed of compact sandy limestone, weathering white; plant-like markings. Limnæa (a few); Paludina (sm. sp.)	1	0
4.	Grey and carbonaceous clays, dark and laminated, with sand in the lower part; light green in the upper 2 feet, where they are compact and marly, and separated from the lower 12 inches by a band of Cyrena obtusa, with both valves joined. In the top part of the dark clay Cerithium (plicatum ?), Melania striata, Cyrena semistriata, &c. The lower 6 inches full of Limnæa, Planorbis discus, P.	3	0
5.	Cream-coloured cavernous limestone, with a hard brecciated and concretionary cap, 6 to 9 inches thick, on the top of the bed, which weathers with a very irregular surface. Limnæa, numerous Taxites and Planorbis (sm. sp.), Chara tuberculata, especially 2 feet from the top. Emits a bituminous odour when struck (No. 3. of Professor Forbes' section, p. 52.) - - - - - 4 ft. to	6	0

	Ft.	In.
6. Soft white earthy limestone, with a few casts of shells, Planorbis, Limnæa, Fish - - -	2	0
7. Concretionary cream-coloured limestone, with an uneven surface above and below; weathering irregularly, and emitting a bituminous odour when struck. Chara, Limnæa longiscata - - - - - 4 ft. or	5	0

Between Watch House Point and Ryde the Bembridge limestone is only seen in one or two places; in the road between Fairy Hill and Nettlestone Green traces of it appear, and in an old pit, nearly covered with grass, S.E. of West Brook Farm, a dark carbonaceous clay occurs, similar to that described by Professor Forbes as forming the lower part of the Bembridge marls at Foreland.

About 200 yards south of the sea wall, at the west corner of Apley Wood, an earthy limestone of the ordinary Bembridge type has been quarried beneath the site of some unfinished houses, the basement storeys of which remain. This was, probably, the lowest bed of the Bembridge limestone, but the place is so covered with underwood that nothing more can be seen now than the unused blocks lying on the surface, which are from 15 to 18 inches thick, and contain Limnæa, Chara, &c.

From this point to Ryde and its immediate neighbourhood the position of the limestone is concealed by gravel, or cannot be traced owing to the enclosed nature of the land.

Mr. Barrow, of Ryde, states that he never remembers stone to have been found in making excavations in the town, except in George Street, where, in laying down some drains, stone was met with in every respect identical with the (Bembridge) limestone of Binsted.

At Binstead, in a quarry newly opened in the wood west of the church, and opening to the sea, the upper part consists of a thick-bedded nodular shelly limestone, with Bulimus ellipticus, Limnæa, Cyrena or Cyclas, Planorbis (like rotundatus) resting on soft sandstones and hard calcareous flaggy beds, sometimes well laminated, and containing teeth of Anoplotherium, claws of lobster, Paludina orbicularis, P. (small sp.), Limnæa, and a small Planorbis.

The upper part of the quarry is made up of green marls and an irregular surface of Limnæan limestone, which is covered with from 1 to 4 feet of ferruginous loam, almost free from flints. There are, however, a few small scattered flints in the loam, generally in the lower part, which is clayey, while in the upper half are lines of small fragments of limestone with an occasional rounded pebble. In the quarries between the above and the road to Ryde, under the rubbish, is a concretionary shelly limestone, resting on sandy and siliceous beds, with short layers of clay, beneath which are 4 ft. 6 in. of grey flaggy sandstone, forming the bottom of the quarry. The Binsted limestone was formerly highly esteemed as a building stone, and has been used in the construction of several churches in Sussex, Quar Abbey (I. W.), the interior of Winchester Cathedral, Lewes Priory, Yarmouth Castle (I. W.), an old Saxon ruin at Southampton noticed by Webster, &c. &c.

The greater part of the best stone has been quarried away, and houses have been built upon the site of the old workings west of Stone-pits Farm.

From Binsted Church the limestone runs in a direction nearly parallel with the coast line to Fish House, between which and Quar Abbey blocks of it lie scattered on the shore; similar blocks form ruins at the base of the cliffs beneath the wood on the other side of Wootton Creek, and again for some distance on both sides of King's Quay.

In the wood west of King's Quay, by the side of the carriage road to Osborne House, the limestone reappears, containing Chara and Helix, with Limnæa, and resting on red and green clay. Also, in two other places in the same direction, in an old pit in a notch on the north side of a small wood; and again, where it had been ploughed up to the surface, in a notch on the south side of a large wood nearly west of Barton Farm. Beyond this last locality the high ground is covered with a thick deposit of gravel, and all further traces of the limestone are lost as far as West Cowes, where it forms a ledge at sea opposite the Parade, and skirting the shore to Egypt, dipping 10° S.E.

Thence to the Point in Thorney Bay it occupies either the cliffs or the shore, and is easily recognized by its fossils (Limnæa, Chara, &c.), and the resemblance it bears to the ordinary characters of the Bembridge limestone. At this point it dips 35° S. of E. 5°, and stretches out to sea in a direction 30° S. of W., reappearing again at Hempstead Ledge, which is formed of three hard beds with soft beds between, which are marked at sea with a white buoy. It contains numerous Limnæa longiscata, Chara, Planorbis, &c., and dips 25° W. of S. 5°.

Westward of the River Yar, the Bembridge limestone forms a series of outliers, the largest and most important of which (about a mile long) is that of Headon Hill.

A thick covering of sand and gravel, forming the crest of the hill, entirely conceals the limestone on the south, but on the north side it reappears in the face of the cliff, and is displayed there nearly to Tollands Bay, better than at Sconce or Cliff End. As usual, it varies greatly in character and composition, sometimes being hard, white, and compact, at other times of a softer, more tufaceous nature, while not unfrequently it becomes conglomeratic and brecciated and is traversed by curious minute and irregular lines and cracks. Bulimus ellipticus, Helix, Planorbis, &c., have been collected from these beds by Mr. John Cotton, of the Geological Survey, mostly in the condition of casts, but the shell is sometimes replaced by calc spar, which also occurs in the form of crystals lining and filling small cavities in the stone. The total thickness of these lower beds is from 15 to 16 feet.

Resting immediately on them, at Headon Hill, is a greyish-green marl, with Cyrena obovata, with both valves in contact, passing upwards into a soft, unctuous, earthy limestone, containing Planorbis and a large Limnæa, which again passes upwards into very tenacious grey clay,

weathering brown and black, and carbonaceous on the top. In thickness the above are very variable, even within short distances, the limestone being sometimes as much as 3 feet, while the clay resting upon it varies from 3 to 14 inches. In one place, however, where the three formed but a single bed, the aggregate thickness was 3 ft. 6 in., viz., clay, 6 inches; limestone, 1 ft. 10 in.; and green marl, 1 ft. 2 in.

Above the carbonaceous clay is a soft cream-coloured earthy limestone, also containing Limnæa and Planorbis. The thickness of this upper limestone, which has apparently a denuded surface, varies considerably, but from 5 to 8 feet of it appear from beneath the white sands, forming the lowest member of the gravel series which constitutes the summit of the hill.

In a section pointed out by Mr. Keeping, further north, the Bulimus limestone is very uneven and irregular, and is covered in places with brown and black carbonaceous clay, filling the irregularities in its surface. The green clay with Cyrena above, the Bulimus limestone, is from 1 ft. 9 in. to 4 feet thick, and it contains a layer of Cyrena 15 inches from the bottom of the bed, while the limestone, which (in addition to Limnæa and Planorbis) contains Cyrena in the lower 3 inches, is only 1 foot thick. The clays above are very irregular, and vary much in thickness. The average amount may be taken at 2 feet, the lower 6 to 9 inches of which is brown clay, becoming occasionally dark and carbonaceous towards the bottom, and dark grey carbonaceous clay 6 to 15 inches; the upper 6 to 9 inches of which is frequently lignite; 2 or 3 inches of sand, with carbonaceous laminæ, succeeded by green marl, complete the section. Hard thick beds are quarried at the eastern extremity of this outlier.

Another detached mass of limestone, commencing a few yards east of that just described, extends nearly half a mile further in the same direction. In the quarry at the western end 12 feet of white stone, sometimes hard and chalky, sometimes earthy and conglomeratic, rest on a bed of yellow sand. Mr. Cotton, who has collected the fossils of the Isle of Wight for several years, states that the most perfect specimens of Bulimus ellipticus are procured from this quarry.

In another quarry lately opened at the opposite extremity of this outlier, 3 feet of earthy limestone are seen in the upper part, between which, and a similar bed of soft earthy limestone 15 inches thick, is interposed a parting (2 to 4 inches) of green clay with crushed shells; another parting of green clay follows, below which is a bed of rubbly, brecciated, and conglomeratic limestone. The pebbles of limestone, which are largest above, gradually decrease in size towards the lower part, when they become very small. The thickness of the bed is 9 inches, but sometimes it swells out to 18 inches, when it contains large angular fragments, the interstices between which are filled with smaller rounded shot-like pebbles of limestone. The thick beds of white earthy limestone, which are the next in succession and the lowest seen, are also conglomeratic and brecciated, about 2 feet below the base of the rubble just described, and contain a brown hard mineral like that in the corresponding beds at Whitecliff Bay.

Limnæa and Planorbis are found here ; the general dip is 8° in a direction 25° W. of N.

A third outlier, nearly three-quarters of a mile long, covers the high ground upon which Hill Farm is built. A pit has been dug into it at the end of the lane running in a N.W. direction from the farm. In the road to More Green casts of Limnæa, Planorbis, and small Helix have been collected. Here it rests on green clay and has an irregular gravel-covered surface, but a short distance further north it is overlaid by green clay containing comminuted fragments of Cyclas or Cyrena. At its northern extremity the limestone is cream-coloured, soft, and earthy (somewhat similar to dried mortar), becoming, however, occasionally harder in places, and assuming a kind of tufaceous character. Here it is based on red clay.

Halfway between this outlier and Norton there is another inconsiderable patch of limestone similar to that last noticed.

The narrow strip which constitutes the limestone of Sconce has been sufficiently described by Professor Forbes, and requires no further notice. It nowhere affords a good section, and chiefly appears in the slips from the higher grounds and in a few blocks on the shore between Norton Ferry and the battery at Cliffend, which contain Chara, Helix, Limnæa, small Planorbis, &c.

The only other locality within the area under examination where the Bembridge limestone may be expected to occur is in the hill between Freshwater and More Green, but it is not seen there, being probably concealed by gravel and grass.

It now only remains to describe the Bembridge limestone in the interior of the island.

Before doing so, it may be as well to observe, that it is not unlikely that the valley of the Yar, extending from Yarmouth to Freshwater Bay, may be the result of a fault which has produced an upthrow of the strata on the west side of the river. At all events, in tracing the boundary of the chalk in that direction, there are appearances from which the presence of a fault may be inferred. In Freshwater Bay the chalk projects farther towards the south on the west side than it does east ; and on the northern escarpment of the Downs, for half a mile, there are terraces resembling huge steps, which in Dorsetshire have been observed to accompany lines of disturbance ; or, more correctly, wherever the chalk escarpments were found to be so converted into terraces a fault was invariably discovered within a short distance, the direction of which was parallel to their general course.

Whether such a fracture in the strata really exists, it is impossible to pronounce with certainty. If the cliffs were united at Freshwater Bay the difficulty would be easy of solution ; but at the place in question they terminate and are separated by a narrow interval of shingle beach, close to which is the source of the river. But for this barrier the sea would flow into the valley at both ends, and the land to the west would constitute a separate island, and might again be called the Isle of Freshwater, a name by which it appears to have been known two centuries and a half

ago. South of Yarmouth the Bembridge limestone reappears, for the first time, in the bed of the mill stream, where it dips a few degrees east of north 3°, and is overlaid by green marls. From the head of the mill dam both its upper and lower boundaries may be traced more easily than in any other part of the island.

The junction between the limestone and the Bembridge marls follows a course nearly parallel to the road from Thorley to Dodpits, which is based upon the former, and on either side of which it may be seen throughout the entire distance at various places; on the south side of the road the lower boundary is more irregular in outline.

In a quarry by the side of the road from Shalcomb Down to Wellow (on the top of the letter S in Isle) some of the limestone is earthy and chalky, with small concretions and calcareous spar, while some is of closer texture, brown, and emitting a bituminous smell when struck. Limnæa longiscata, Planorbis, and Chara tuberculata, are the prevailing fossils. Near Churchill earthy limestone rests on harder beds, with included siliceous fragments. At Dodpits thick beds, with a dip 4° slightly east of north, are quarried for building stone. The whole of the above area is free from gravel, and the limestone caps the summits of broad tabular hills 1¼ miles wide at their greatest breadth, which have a gentle slope towards the north, the inclination of the ground corresponding nearly with the dip of the beds in that direction.

The limestone furnishes a better agricultural soil than most of the other members of the fluvio-marine series, and the greater proportion of it is converted into arable land.

From Dodpits to Stoney Cross the amount of dip increases, and the width of the limestone at the surface becomes proportionally diminished.

It is still, however, well seen in old quarries on the north side of the lane, as well as in the lane itself, opposite Street, and Place, dipping 3° west of north 30°, and is either cream-coloured, soft, and earthy, or darker, harder, and more compact. Those fossils which are rare at Binsted are here comparatively plentiful. Amongst others, Paludina orbicularis is very abundant, together with Bulimus ellipticus, Planorbis discus, Limnæa longiscata (all in the state of casts), Chara, &c.

East of the road from Stoney Cross to Fulholding farm, the course of the limestone becomes greatly obscured. It can, however, though with difficulty, be traced in a direction parallel with the strike of the lower strata.

On the west side of the brook, running through the wood, west of Fulholding Farm, it dips about 10° west of north, and in a new cutting through the wood, north of Swainstone, it reappears with a reversed dip, the section being as follows in a descending order:—

No.	Ft.	In.
1. Bembridge limestone, dip 56°, 10° east of south.		
2. Tenacious brown and green clay, about - -	7	0
3. Earthy calcareous sandstone, irony in upper part - -	1	0
4. Light green tenacious clay - - - -	3	0

No.		Ft.	In.
5.	Impure earthy limestone; sandy and white in the upper part, more ferruginous towards the base (casts of Paludina); strongly resembling the Osborne beds - - -	1	6
6.	Pale green marly clays, with occasional concretionary nodules of iron.		

Probably this disturbance is only local; at all events, from the absence of sections, the presence of gravel, and other difficulties in the ground, it could not be traced any further. From the south-east corner of the wood under Great Watchingwell, the limestone follows nearly a straight line to Great Park, passing beneath the farm buildings, eastward of which to Gunvelle the only indication of its presence for a considerable distance is afforded by fragments occasionally brought up by the plough in the fields; and from thence to Newport, and for a considerable distance beyond, all traces of it were lost.

The first re-appearance of the limestone in East Medina is in a small opening in a field opposite Little Duxmore farm, where it is vertical, resting on sand, and having a direction one or two degrees south of east. Its character is that of an earthy white limestone, sometimes tufaceous, sometimes marly and harder, with patches of a pinkish siliceous mineral; sometimes it becomes a hard white limestone, with Limnæa longiscata, Paludina globuloides, small Planorbis, &c. It is also ploughed up in the fields between Little and Great Duxmore, and thence to Combley Woods, between which and Newport no traces of it were discovered after much diligent searching. West of the road from Rowlands to Messly Down it was not seen again for some distance, but obscure traces of it were observed between the road from Ashey Down to Ashey Farm, and the lane from the farm in a southerly direction to the waterworks, between which points a narrow ridge extends, the course of which is generally indicated by the comparative luxuriance of the crops growing upon it. Otherwise, the surface indications of its presence are few, the blocks of limestone brought up by the plough being mostly removed from the fields.

South of Lower Nunwell, in a ditch under a newly-made fence, rubbly limestone, with small earthy concretions, was seen again, nearly in a vertical position; above it, a Cyrena obtusa was found in brown clay, and also a fragment of stone resembling the concretionary cap mentioned by Professor Forbes as occurring on the top of the upper bed of Bembridge limestone below St. Helen's, at the entrance of Brading Harbour.

Apparently red and green mottled clays come in beneath the limestone, and upon it green marls with white crumbly concretions, above which rests another series of red and green marls. Nothing more is discernible of the limestone for a considerable distance. A little west of Brading Church it has been slightly worked, and opposite the church it crosses the road and extends in a direction parallel with the lane (on the south side of which it has been quarried) to the sea wall, dipping about 20° east of north, at an angle of 45°.

On the opposite side of Brading Harbour the limestone shows itself again from beneath red and green marls on the shore, at the south end of the copse; and in addition to the locality mentioned by Professor Forbes, near Wolverton, again at a point midway between Bembridge Farm and Whitecliff Bay, the name of which is not given on the map.

In conclusion, it may be observed that between Watchingwell and Brading (compared with the district to the westward of the former place) the Bembridge limestone plays but an inconspicuous part. The same remark applies to the whole of East Medina, for the entire area in question derives its supplies of stone either from the blocks found loose on the shore, or from the quarries at Binsted; and the only locality where the Bembridge limestone was discovered after diligent searching, besides those already described, was on the Royal domains, in the brook, and in a newly-made watercourse adjoining, between Alverton Farm and Palmer's Farm, a slight distance north of the road between the two places.

Bembridge Marls at Whitecliff Bay and Foreland Point, measured by Professors Ramsay and Morris and H. W. Bristow.

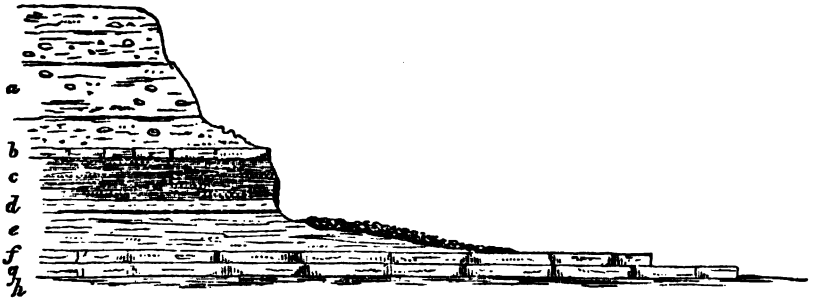
Resuming section IX., see p. 113, from the crumbly white marl which forms the upper bed of the Bembridge limestone at Whitecliff Bay, the order of succession of the Bembridge marls is as follows, commencing with the lowest beds, and measuring upwards:—

No.		Ft.	In.
1.	Light green marl, with a line of small irregular concretions, 2 ft. 6 in. from the bottom; and full of crushed Cyrena in the upper and lower parts	4	6
Marine Bed 2.	Hard green shell marl (harder in places, and forming a compact rock), containing casts of Cerithium - 1 ft.	1	6
Marine Bed 3.	Light green sands, with nodules, Ostrea Vectensis, chiefly towards the middle - 6 inches to 1 foot		
4.	Ferruginous sands and grey clays	0	2
5.	Greenish-grey carbonaceous clays	0	9
6.	Hard whitish marl	0	6
7.	Dark grey bituminous sands, laminated with ferruginous sand	1	6
8.	Band of small Cyrena	0	1
9.	Lighter clays, laminated with ferruginous sand	?	
10.	Red and green marls (with white bands) of considerable thickness, and forming a tumbled, grass-covered cliff		

On the shore, about 300 yards from the Point, the beds numbered 5 and 6 contain Cytherea incrassata, Cyrena semistriata, C. obtusa, and form the base of the cliff; 4 feet of them, with hard gritty bands, being seen beneath the hard marl No. 6. The marine bed is concealed by the pebble beach, and the Bembridge limestone forms the ledge stretching out at sea.

A short distance further east, the upper marl of the Bembridge limestone series becomes in places harder and more calcareous, and with the limestone, which is crowded with Limnæa to the very surface of the bed, constitutes the ledge. The marine bed (Woodcut XVIII.) reposes upon

XVIII.



a. Gravel.
b. Hard white marl.
c. Black carbonaceous clay, with gritty sands.
d. Band of Cyrena semistriata.
e. Position of marine bed obscured by shingle beach.
f. Upper bed of Bembridge limestone: Limnæa.
g. Compact marly limestone. Small Paludina.
h. Green marl.

the upper limestone, and forms, sometimes, a flat ledge between the gravel beach and the sea, while the cliff is composed of dark bituminous clay (No. 7), based upon No, 6, which here becomes a white indurated septarian marl. The marine bed is 4 feet below this indurated marl (No. 6), above which last are 2 feet of clay to a band of Cyrena semistriata at the base of the cliff, associated with Cyrena obtusa with both valves, C. pulchra, Cerithium, &c. Between this and another band of Cyrena semistriata intervene 3 feet of a lighter coloured clay, containing Cyrena obtusa with both valves, and occasional patches of crushed Paludina. Above the upper band of Cyrena semistriata there are six inches more of clay, containing bands of Melania.

Close to the Point, Folliculites and Cyrena obtusa were collected from the dark carbonaceous clays, upon which were two feet of green marl, succeeded by two feet more of marly limestone, underlying the marine bed, which is here concealed by the gravel forming the beach.

At the Point the indurated marl (No. 5) runs into the cliff. The latter is composed of the grey carbonaceous clay, capped with flint gravel, which a short distance further constitutes the entire thickness of the cliffs.

St. Helen's.

At Bembridge Point the limestone passes into the sea, and reappears at St. Helen's, close to the old church tower. The upper bed has an uneven undulating surface, and is covered with a cap containing oysters through-

out its entire thickness, which is very variable. Here the section in an ascending order is as follows :—

	No.	Ft.	In.
Bembridge Marls. Limestone.	1. Green marl		
	2. Limestone, with Limnæa and Chara	2	0
	3. Cap, above limestone, containing oysters and Limnæa	0	6
	4. Clay, with Cerithium and Melania muricata	1	0
	5. Hard white marl	0	6
	6. Clay	1	6
	7. Clay, with patches of Paludina; a fossil band about three inches from the bottom, with Cyrena obtusa and fragments of wood	1	6
	8. Cyrena band. Cyrena obtusa, C. pulchra.		

On the south side of Watch House Point, the surface of the limestone is also irregular, and contains concretions. On the top of the bed is a menilite-like looking substance, 1 inch thick. The following section is taken in ascending order, commencing with the lowest bed seen.

Bembridge Limestone.

No.	Ft.	In.
1. Hard green marl, with concretions in the lower part	2	6
2. Earthy limestone; the upper part soft and of variable thickness. Planorbis discus in the upper part, Limnæa throughout	1 6 to 2	0
3. Compact greenish clay (slightly bituminous), with fragments of Cyrena, and now and then a perfect valve	0	9
4. Dark laminated clay; the lower part of a lighter colour, and more sandy	1	3
5. Limestone, irregular, marly, and most compact in the lower half of the bed, which is, also, the least fossiliferous. Full of Chara, with a few Limnæa and Paludina globuloides. The upper 2 feet more ferruginous, and less indurated, and frequently marked by the abundance of Limnæa	4	0

Lower Bembridge Marls.

6. Brown, sandy, and very ferruginous clay, full of oysters and Cyrena	1	3
7. Brown unfossiliferous clay	0	3
8. Dark laminated clay	0	4
9. White indurated marl of variable thickness	4 to 0	6
10. Dark Cyrena clays, ferruginous towards the upper part	3	0
11. Green clays.		

South of Little Apley the Bembridge Marls occupy the higher grounds, but, owing to their being covered with 30 feet of gravel, they are nowhere seen upon the surface. The strata at Ryde are similarly concealed, but

Mr. Barrow states that in the upper part of the town the gravel overlies clay of a bright green colour, full of the fragments of half-perished bivalve shells, which, from the specimen produced by him, would appear to be Cyrena obtusa. Near Ninham, south of Quar Wood, green clay appears from beneath the gravel at the new brick pit.

At New Barn, between Osborne and Norris, the blue clay seen in a shallow opening in the ground, containing Cyrena obovata, C. semistriata, Melania, &c., most likely belongs to the Bembridge marls.

The Bembridge limestone is exhibited in the bed of the brook, and also in the cutting for a new watercourse, which runs through the wood between Alverton Farm and Palmer's Farm, a short distance north of the road, presenting its usual appearance, and containing Limnæa, &c. Green clay, with calcareous shelly bands, rest on the limestone there, and again further south at the termination of the wood on the west side of the brook. In both places the fossils, which are in the form of casts, are similar,—Cyrena semistriata, C. pulchra, C. transversa, Cytherea incrassata, and Mytilus affinis, being the most common shells.

By the corner of the wood south of Alverton Farm the gravel is 10 feet thick, and overlies a greenish-grey clay, apparently without shells, but containing flat reed-like plant impressions, similar to those noticed in No. 12 of the Hempstead section.

The only locality where a perfect section of the entire thickness of the Bembridge marls is displayed, is along the shore under Hempstead Cliff, at low water.

Bembridge Marls of Hempstead.

Measured along the Shore at Low Water.

	No.	Ft.	In.
B	1. Black Band (base of Hempstead series)	1	9
	2. Green clays, with large bands of Paludina lenta	4	6
	3. Ironstone	0	9
	4. Clay	4	0
	5. Clay with Paludina	4	6
	6. Concretionary ironstone	0	3
	7. Clay with Paludina	4	6
	8. Clay with two or three small black bands	2	6
	9. Ferruginous brown sandy clay, with Paludina at base, thickness variable	0 to 0	6
	10. Thin bituminous bands, with reed-like plants, and a layer of Paludina lenta below, filled with green clay	0	1
	11. Grey clay, with short zones of Melania Forbesii and nodules containing Paludina lenta	3	0
F	12. Band of scattered nodules of iron pyrites, overlying verdigris-green clays, with bands of Paludina lenta (occasionally of very large size), Melania Forbesii	5	0

No.		Ft.	In.
13.	Dark grey clays, with Paludina and numerous oval seed vessels, and containing thin carbonaceous sandy bands, with (reed-like) plant impressions, Cypris, Paludina, Planorbis immediately overlying a layer of large Limnæa. Altogether a freshwater deposit	3	0
14.	Bands of Melania turritissima, Planorbis, and Paludina	0	1
15.	Greenish shaly clay, with concretions of indurated marl, and containing near the base a band of Melania turritissima, M. costata, Melanopsis carinata, Paludina	4	0
16.	Hard shelly band, chiefly made up of Melania turritissima, a few Melanopsis, and fragments of Fish	0	3
17.	Light grey-coloured clay, with bands of compressed shells, chiefly Paludina	2	0
18.	Sandy band, full of Cyrena obtusa (with both valves), Cerithium ——— and Melanopsis fusiformis	0	9
19.	Pale greenish shaly clay, with a thin band of Melania turritissima 6 inches from the top, and 1 inch bituminous band at 3 feet. Compressed Carpolithes, Melania turritissima, Melanopsis carinata	6	0
20.	Sandy clay, with Melania muricata, M. turritissima, Melanopsis; 0 3 resting on sandy clay, almost entirely composed of Melania muricata, with a few broken Cyrena, and some Melanopsis	0 4 to	0 7
21.	Bluish, selenitic, irregular shaly clay, with a band of Melania turritissima and Melanopsis carinata, 2 inches from the top. Paludina	3	0
22.	Indurated greenish marly clay, with bands of Paludina lenta	4	6
23.	Greenish clay, with 2 bands of broken Cyrena obtusa, and C. semistriata, and on the top a bed of Melania muricata, with scattered Melanopsis, and occasional Cerithium (new species)	0	9
24.	Green clays, Melania turritissima, with scattered Melanopsis and Melania muricata, mixed with patches of Cyrena semistriata, C. obtusa, Fish remains, &c., about the middle 4 inches	1	0
25.	Green clays, with Melania muricata, M. turritissima, and numerous Melanopsis carinata and Paludina lenta	1	6
26.	Verdigris-green clay, with Cyrena semistriata	1	0
27.	Bright green clays, with Cyrena semistriata on the top	2	0
28.	Bluish-green clays, with bands of Melania muricata and Cyrena obovata	1	6
29.	Hard sandy green marl, with scattered Cyrena semistriata	0	6
30.	Verdigris-green clays, with 5 bands of Cyrena semistriata and Melania	1	6
31.	Greenish clay, with 2 marked bands 1 and 2 inches thick, full of Melania muricata (small sp.), occasional Cyrena pulchra, and a few Cyrena semistriata	1	0

No.		Ft.	In.
32.	Green clays, with Cyrena semistriata (finely preserved), C. pulchra, and Melania - - - - - -	0	9
33.	Dark clay, with soft green sandy concretions, 6 inches; greenish clay 1 foot. Scattered Cyrena obovata - -	1	6
34.	Blue clay, with small Cyrena (obovata ?) Melania muricata and Melanopsis - - - - - -	1	0
35.	Bembridge limestone in 3 beds, with softer beds between, forming a ledge (Hempstead Ledge), out at sea, in the direction of the Buoy, and containing numerous Limnæa longiscata, Chara, &c.		

Section of a Portion of the Bembridge Marls measured in a projecting Cliff close by the shore, opposite Hempstead Ledge.

	1. Laminated clay with occasional concretions, and a white bed in the middle, which is full of fish remains at the		
F	base. One foot below the fish bed and ranging downwards, clays with seven layers of Paludina, and occasional layers with Folliculites - - -	10	0
	2. Grey clay with dark bands, probably the carbonaceous bands seen on the shore; and three thin bands of shells with Planorbis and Melania Forbesii - -	3	0
	3. Light-coloured laminated clay - - - -	3	0
	4. Greenish clay with irregular bands of Paludina - -	2	0
H	5. Hard, ferruginous shelly bed. Paludina, Melanopsis, Melania turritissima, Fish - - - -	1	6
	6. Light grey clays, with several bands of Paludina, and Melanopsis - - - - - -	3	0
	7. Band of Cyrena obtusa - - - -	0	6
	8. Bed containing ferruginous concretions, and a thin band of Paludina with fish remains near the top -	2	8
	9. Dark carbonaceous band, with small Melania and Melanopsis carinata - - - -	0	1
	10. Light laminated clay, with patches of Melania muricata, M. turritissima, Melania Forbesii - - -	2	6
	11. Shelly clay loaded with Melania and Melanopsis, equivalent to the similar bed No. 19 of the preceding section - - - - - - -	0	6

Section of Bembridge Marls exposed in a projecting Point in the Cliff near Hempstead Ledge.

Moved ground, marly; with chalk flints at the base

1.	Layer of comminuted shells - - - -	0	1
2.	Greenish and ferruginous clays, weathering brown -	5	0

	No.		Ft.	In.
	3.	Ferruginous band, probably hardening into pyrites on shore, with Paludina lenta, Planorbis (small sp.), Melania (turritissima ?), Melanopsis - - -	0	3
	4.	Laminated clays with occasional concretions - -	5	0
F	5.	White marly band with ferruginous band containing fish remains at the base (3 inches) - - - -	9	6
	6.	Laminated clays with a layer of Paludina at 1 foot, and seven layers at 2ft. 6 in., with occasional layers of seeds (Folliculites) - - - - -	5	0
	7.	Grey clay, with darker bands (probably forming some of the minor carbonaceous bands on shore containing plants and Unio), and three bands of shells with Melania Forbesii and Planorbis - - - - -	3	0
	8.	Light-coloured laminated clay - - - -	3	0
	9.	Greenish clay, with irregular bands of Paludina - -	2	0
H	10.	Slightly ferruginous, hard shelly band; Paludina lenta, Melania turritissima, Melanopsis, Fish - -	0	6
	11.	Light grey clays, with several bands of Paludina and Melanopsis - - - - - -	3	0
	12.	Bed full of Cyrena obtusa - - - - -	0	6
	13.	Clay with ferruginous concretions, and near the top a thin band containing Paludina and Fish - -	2	6
	14.	Dark carbonaceous band with Melania and Melanopsis carinata - - - - - -	0	1
	15.	Light-coloured, unctuous, laminated clay, with patches of shells, Melania muricata, M. turritissima, M. Forbesii, &c. - - - - - -	2	6
	16.	Shelly clay abounding with Melania and Melanopsis, and the equivalent to a similar band beneath a carbonaceous band seen on the shore; No. 19 of Hempstead Shore Section - - - - -	0	6

North of Stonewell, the Bembridge marls are worked at Ningwood Brickyard, not far from their junction with the limestone. The lowest bed, a light greyish sandy clay, burns to a red brick, worth about 20*s.* per 1000; but the bed above, a greenish marl weathering whitish, about 12 feet thick, furnishes a white brick worth 42*s.* per thousand. Before burning the latter, it is necessary to wash it in a mill, in order to get rid of the calcareous matter it contains, which is carried off by the water.

Bands of Cyrena semistriata occur both in the clay and marl, but more abundantly in the latter. The shells in general are in a perished state, and are scarcely ever found perfect.

West of Ningwood, green and brown clay, lying higher in the series than the beds just described, is used for making tiles.

Inside the wood, north of Bouldner, green sandy clays weathering brown appear along the shore, containing Cyrena semistriata, C. obovata,

Paludina lenta, Melanopsis, &c. These are probably near the base of the Hempstead series.

At the west corner of the same wood, grey laminated clays are seen, and at the east end of the commencement of the next cliff five or six chains further towards Yarmouth, laminated grey clay, with bands of ironstone containing Paludina and Melanopsis, make their appearance.

The shore between the wood in question and the road to Thorley is thickly strewed with fragments of clay ironstone, abounding with Paludina, that have been derived from the destruction of the cliffs.

Osborne Series.

The strata composing the Osborne series were better displayed at Whitecliff Bay in the summer of the present year (1856) than at the time of Professor Forbes' visit, when they were concealed by landslips, or in grass-covered undercliffs. The following is a list of the beds then observed taken in an ascending order :—

	Feet.	In.
Green clays ; Paludina, Melanopsis - - - about	15	0
Fine cream yellow limestone, running out to sea in a direction 10° N. of E. No fossils observed - - - -	1	0
Olive-green clay, Melanopsis carinata, Paludina lenta - 15 to	18	0
Dark green marls - - - - - -	8	0
Shelly band, large Paludina, Melanopsis carinata - -	4	6
Dark grey sandy clays - - - - -	3	0
Green clays - - - - - - 3 or	4	0
Red and green mottled clays, with 1 to 2 inches of clay ironstone on the top of the bed - - - - - 18 or	20	0
Dark olive-green clayey sand - - - -	3	0
Grit - - - - - - -	1	0
Dark bituminous clay, with Limnæa in patches - -	2	0
Total thickness of Osborne beds - - -	79	6

Nothing more is seen of the Osborne strata between the termination of the above section and Watch House Point, where they again emerge from beneath the Bembridge limestone.

At Summerhouse Point, thick-bedded sandstone (No. 11 of Professor Forbes' Nettlestone section) forms the base of the cliff, containing in some parts bands of small rounded flint pebbles ; in others, layers of partially decomposed angular flints. The upper part is full of broken shells, and patches of comminuted shells occur about 2 feet from the top, which is calcareous, and less hard than the lower portion of the bed. There are, also, occasional fucoidal markings and large irregular concretions, which, weathering unequally, cause the rock to assume a honey-combed cavernous appearance.

The boathouse is built upon green clay, containing bands of Paludina and Melania excavata, resting upon the upper part of the thick-bedded

sandstone already described, which here becomes the limestone, with Chara and Limnæa, that is quarried on the sea shore for building-stone.

Westward of the Point this limestone changes its character, and becomes indurated marl of an ochreous colour, containing Chara, as before, and greenish-grey argillo-calcareous nodules. This change of mineral character apparently escaped the notice of Professor Forbes, who has described the bed both under its normal and altered aspect in his section of the Nettlestone Grit, at page 74-75, as two distinct and separate beds (Nos. 9 and 10).

At Nettlestone, the rocks at the Point are thick-bedded silicious limestones, soft in some places, and made up of comminuted Paludina lenta; in others, passing into hard silicious grit. They form large blocks upon the shore 8 feet thick, weathering very unequally into irregular cavities, and containing fossils with the shell preserved. In the freestone, about 2 feet 6 inches from the top, there is a well-defined band of Limnæa, 6 inches thick. The lower part is indurated and cavernous, and passes into hard grit.

Under the Flagstaff, the shelly limestone constituting the upper 5 feet of the bed is made up almost entirely of comminuted Melania excavata, with bands of Paludina lenta, the whole resting upon ripple-marked flaggy silicious grits.

West of Nettlestone Point the hard beds, with large and small Paludina and Limnæa, supporting the pathway in front of the Crown Inn, become thick-bedded sandstone, with calcareous bands, which are sometimes made up of comminuted shells, and are the same beds as those beneath Summer House Point.

From Nettlestone to the next Point to the westward, opposite Puckpool Farm, there is a broad expanse of bright green marl, uncovered by the sea at low water, and free from blocks of stone. These marls are generally concealed from observation by a thin layer of sand; most likely they were so covered at the time of Professor Forbes' visit, or they would not have escaped his vigilant eye.

From the notch in the coast, near the commencement of the woods, beds with Chara dipping W.S.W. 2° appear at intervals on the shore and under the sea wall, as far as the semicircular projection half way along the bay.

At the west corner of Apley Wood a bed of calcareous sandstone, about 4 feet thick (full in places of casts of Paludina, associated with numerous large Unio, Limnæa, Planorbis, and occasional bones of Turtle), appears on the shore beneath the sea wall. The shells, which are as much crowded as in Sussex marble, are sometimes filled with a greenish marl, and the rock itself is somewhat ferruginous, and of a pale ochreous colour.

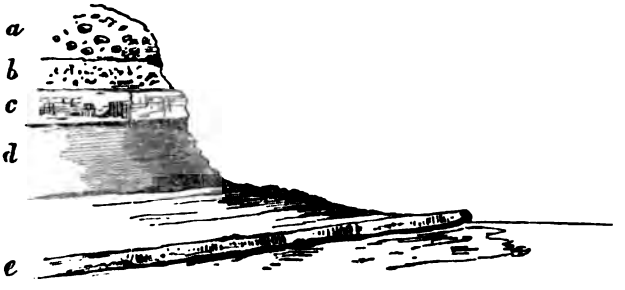
It rests upon ragstone similar to that at Nettlestone, 10 feet or more thick, under which is sandstone in layers 18 inches thick to a depth of 10 or 11 feet. Under all is a strong greenish-blue clay for 30 feet more,

which contained apparently crushed Paludina. Much of the stone used in the construction of the sea-wall has been got up on the shore here, opposite the wood. Red and white clays are based upon the upper bed of stone; they are seen in the cliffs for a considerable distance, and have furnished the earth manufactured at the brick-pits inside Little Apley Wood.

Gravel and the enclosed nature of the ground now conceal the strata for a considerable distance. Half way between Apley and Ryde Pier a few scattered blocks of grit lie under the sea wall, and again opposite the last houses on the west side of the town.

About half a mile west of the pier, sandstone reappears, dipping 10° W. of S. 5°; and at Binsted Point the upper calcareous portion of the thick bed at Nettlestone comes to the shore, capped with green marls, and assumes the character of a hard compact white limestone, with casts of Melania excavata. Beyond the point it forms a ledge on the shore, striking nearly due west, in the direction of Osborne. The shore is red and green marl, as before.

XIX.



a. Gravel.
b. Sand.
c. Grits.
d. Marl.
e. Grit.

Round the Point, 30 feet of red and green marls are displayed at the base of the cliff, supporting hard light green marl with small white concretions; above this succeeds a thin band of perished shells (forming a soft shelly limestone, the greater portion of which is composed of fragments of bivalve shells), with a sort of laminated appearance. The calcareous band contains comminuted Cyrena, Limnæa longiscata, Unio, Melania excavata, Melanopsis, Planorbis discus, &c., with 2 feet of interstratified sands and sandstones and grits above it, the equivalents, probably, of the silicious beds beneath the Bembridge limestone at the Binsted quarries, which have been already described in connexion with the limestone of that locality. 2 feet of soft sand complete the section (Woodcut, XIX.)

From this point, the only member of the Osborne series displayed on the coast for a considerable distance is the red and green marls and clays, which are seen in the cliffs and on the shore as far as Norris.

On the west side of King's Quay the red and green clays in question still constitute the lower portion of the cliffs and the shore, which last is

strewed for about 300 yards with loose blocks of Limnæan limestone (belonging to the Bembridge strata) fallen from the higher parts of the cliff.

From the end of the wood to the Point (denoted on the map by the word "Fossils") the loose blocks of stone on the shore are mostly silicious grits or shelly limestone, derived from strata lower in the series than the Bembridge beds, that is, from the equivalent to the thick-bedded sandstone of Nettlestone Point, the uppermost of the two divisions into which the Osborne series has been divided by Professor Forbes.

The stone at the Point has been already sufficiently described in the text at page 76. Beneath it are green sandy clays with harder marly bands, containing Limnæa longiscata in a good state of preservation. The green marls also contain small concretions.

From the Point, for a distance of 200 yards eastward, these lower beds form the base of the cliff, and the projection of the land there is owing to the protection afforded by the presence of these hard strata at the base of the cliff, and of their ruins which lie piled up on the shore, against the wearing action of the sea.

Where there is no natural protecting influence of this kind the coast line is worn back in a corresponding degree, examples of which will be found on either side of the Point. Eastward of it the red and green marls and clays, between the Bembridge limestone and the Nettlestone grits, opposing comparatively slight resistance, have been more rapidly acted upon, and a slight indentation in the coast line has resulted from their destruction, to restrain which, for the future, the land has been protected from further waste by means of piles and stakes.

On the other side the Point similar influences have been in operation, and the hollow in the outline of the coast, at the end of the combe extending towards the house, is a result of the disintegration of the softer beds of the Nettlestone grits, which, rising with a gentle slope towards the west, are now found gradually occupying a higher position in the cliff.

Between the Point and the landing pier there is an absence of sections either on the shore or inland. The Nettlestone beds are displayed by the landing pier at the back of the house, which appears to be built upon red and green marls. The upper bed of the grits becomes a very shelly limestone, with silicious bands. Tough brown clay, sometimes changing to grey shales, succeeds for a thickness of 3 feet up to a line of nodules of iron.

West of the landing pier, as far as the wall dividing the Royal grounds from those belonging to Norris Castle, the cliffs have been dug back to procure stone for building and for lime. It here becomes very sandy and gritty, and sometimes is made up of the casts of Paludina lenta in calc spar; at other times of a mass of comminuted shells, apparently Cyrena, and it agrees with the description given of the typical St. Helen's beds.

Beyond the wall forming the boundary of the Royal grounds further information respecting the Osborne strata cannot be obtained in consequence of the absence of sections and the thick covering of gravel which is spread over the surface.

The Headon beds, also described by Professor Forbes as having served for the foundation of the sea wall at Osborne, are now concealed from view, and the details of the strata between them and the silicious limestone quarried in the cliffs are obscured by the soil that has been thrown over them for the purpose of forming a grassy slope down to the water's edge.

Headon Series.

With regard to the Headon beds of this locality they will be best examined by commencing further westward, where they first make their appearance on the east side of the river Medina, at the mouth of Cowes harbour.

Due north of East Cowes, a little round the first Point, light green and red sandy clays, with bands of compressed Melania costata and bivalves, forming a shell-marl, have slipped from a higher level on to the shore, and Paludina lenta, Cyrena obovata, Potamides (Cerithium) concavum, one in a silicified condition, lie scattered in great profusion on the beach.

Immediately under these, apparently, and seen also on the shore, are 1 to 2 feet of greenish-grey clays, with occasional sandy laminæ, and numerous bands of Potamomya mingled with a few Paludina lenta, Cyrena obovata, and an occasional C. pulchra.

Bands of crushed Paludina lenta occur lower down, succeeded by bands of Melanopsis, with remains of Fish (scales, vertebræ, and teeth). Green sandy clays follow, with thin pyritised bands of shells, a band of Limnæa longiscata and smaller subordinate layers of Potamomya.

Here the beds undulate, and towards the point above Norris lower beds make their appearance. West of the Point green clays are seen at the base of the cliff 4 inches thick, under a 2-inch band of clay ironstone. These clays contain Melania turritissima ? and a black Cypris. Upon the clay ironstone is a band of Cyrena pulchra and a foot of greenish clay full of Cyrena obovata, occasionally with the valves in contact, and most numerous towards the upper part. Three feet beneath the ironstone there is another similar band separated from the first by green clays, with five or six bands of Potamomya. Below the second band of ironstone green clays, with oysters, succeed, associated with Cyrena pulchra, C. obovata, Cerithium, &c.

On the shore, about 50 yards westward from the wall of Norris, pyritiferous bands of Potamomya underlie the green clay with oysters, and the section may be there continued as follows :—

	Ft.	In.
Green sandy clays, with an oyster band 2 inches thick - -	1	6
Grey sands, fossiliferous in the upper part, where they are also laminated, and passing into ferruginous grit - - -	2	6
Light greyish clayey sands, with 2 inches of Potamomya in the upper part - - - - - - -	4	0
Beds not seen - - - - - 3 or	4	0
Greenish sands, with Melania muricata and Potamomya -		
Greenish clay, with a few Potamomya - - -	1	0

	Ft.	In.
Consolidated and partly pyritised bands of Potamomya, between which are layers of greenish sandy clay full of Chara, fish scales, and Melania muricata in patches, Dip 20° S. of W. 12°	5	0
Light green sandy clay, with comminuted Cyrena - -		

North of Norris, by the sea wall, the beds on the shore are crowded with Cyrena obovata and Potamides; Cyrena pulchra and oysters being somewhat scarce. The dip here is 25° W. of N. 12°.

The shells already noticed as being so plentiful on the beach nearer East Cowes are probably derived from these beds, which are most likely lower than those with consolidated bands described in the preceding section. Opposite the Point they are probably covered by the sea. Hence to the wall separating the Royal grounds from those of Norris the strata are concealed; but on the shore opposite the latter, sands with Potamides, Cyrena, and oysters, again appear dipping 30° W. of S. 25°.

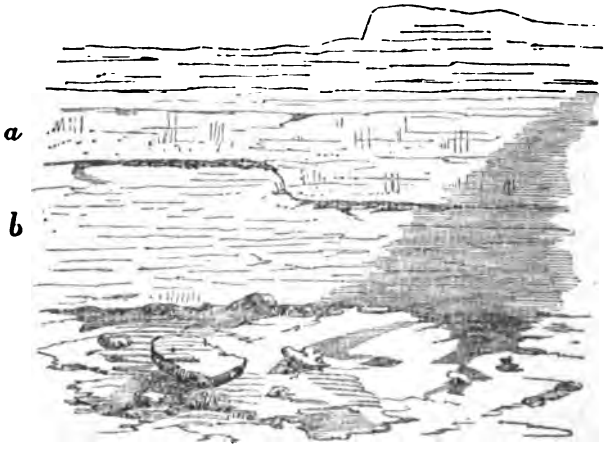
How ledge, between Colwell and Tollands Bays, is formed by a series of faults (each individually of small amount), which cause the limestone to be repeated 14 times on the shore, with an upthrow towards the north, slightly east of which is the general direction of the dip.

Between How ledge and Lynchen Chine, a short distance north of the latter, the softer strata have been violently contorted and squeezed, an instance of which is well displayed in the face of the cliff.

The limestone of How ledge gradually increases in thickness towards the south, and in Tollands Bay and at Headon Hill it forms the lower limestone of the upper Headon series, so conspicuous in the face of the cliff, and so remarkable likewise for the abundance and beauty of its fossils.

Fig. XX. shows the manner in which the limestone (*a*) forming How ledge, suddenly becomes thicker in that locality.

XX.



a. Limestone of How ledge, carbonaceous at junction.
b. Pale marl.

Fault of the Medina Valley.

This valley owes its origin, in all probability, to a fault, which, acting in the direction of its length, has produced a dislocation of the strata, raising those on the eastern side above their original level, or depressing those on the opposite side to a corresponding degree.

The actual position of the line of fault, traversing that part of the valley which is now occupied by the bed of the river, is nowhere visible, but its existence is fully proved by the effects produced.

When making the Geological Survey of the Island in 1852, the writer of these notes was convinced that certain appearances in the physical structure of the district on either side of the river Medina, south of Newport, must be the result of a fault.

At that time the neighbourhood of Osborne had not been examined; and to Professor Forbes is due the merit of having proved beyond a doubt, by his observations there, the truth of what had previously only been inferred.

The Bembridge limestone at West Cowes is nearly at the sea-level, and the higher grounds are occupied by the Bembridge marls, but, on the opposite side of the river, the lowest strata seen, at the level of the sea, belong to the Upper Headon Series, which can be traced along the shore from East Cowes to Osborne.

The amount of vertical displacement to which the strata have been subjected between East and West Cowes cannot, therefore, be less than 100 feet, or the entire thickness of the Osborne Series, and as much of the Upper Headon Beds as is brought up to the level of the sea.

In addition to this relative change of level, the effect of the fault has been to thrust the strata near Newport, on the east side of the valley, more towards the north than those on the opposite side, so that the geological boundaries do not meet; and at the same time to increase the inclination of the beds, which are tilted there at a higher angle than is the case on the western side of the river. (See Plate 8).

The remainder of the tertiaries between the fluvio-marine strata and the chalk is best and most completely displayed in Alum and Whitecliff Bays, in both which localities, being vertical or nearly so, they are most favourably disposed for examination.

Elsewhere, probably the details of no two sections, measured in different places, would afford precisely similar results.

It appears that at certain points, where the disturbing force acted with the greatest intensity, portions of the strata have either been squeezed out altogether, or they have been driven laterally into spaces situated between points where the pressure was not so intense.

The strata in question are alternations of sands and clays of variable degrees of hardness, thickness, and mineral composition bounded on one side by the chalk, on the other by the sands, clays, marls and limestones, which constitute the Fluvio-marine Series.

If the chalk and the fluvio-marine series everywhere opposed the same amount of resistance to the disturbing action, then, supposing the force to be applied at the base of the chalk, at every point of which it acted with equal intensity, and the strata *between* the chalk and the fluvio-marine series to offer everywhere an equal resistance, it is evident the disturbance of the strata would everywhere be of equal amount. These conditions have not, however, obtained, and the results have been modified accordingly.

The chalk has either resisted unequally at different places, or the disturbing agency has been greater in one place than another, and the result is, that the upper surface of the chalk, instead of being thrust forward in a vast inflexible tabular mass, has yielded unequally, forming a series of undulations, or curves, alternately convex and concave, the outline of which, drawn on paper, would be a waving line.

Where the surface of the chalk bulges outwards, so as to present a convex surface to the tertiaries, a greater amount of pressure would be exerted upon them than would be the case if a concave surface were opposed to them.

If the resistance of the fluvio-marine strata were everywhere constant, or nearly so, the result would be that the force exerted by the convex surface of the chalk would have a tendency to relieve itself by squeezing a portion of the material subjected to its influence laterally into the spaces where the disturbing agency acted with less intensity, which would be into the corresponding concavities in the surface of the chalk on either side of each convexity.

In other cases, the degree of force might be so great as to find further relief by squeezing portions of the more yielding strata, subsequently removed by denudation, in an upward direction, towards the then existing surface, or both conditions may have obtained simultaneously, which has most probably been the case.

The truth of the above argument must either be acknowledged, or the thickness of the middle and lower eocene strata must be a constantly variable quantity—diminishing suddenly in one place and as suddenly re-assuming its normal proportions elsewhere in another.

Very frequently the horizontal distance between the upper surface of the chalk and the base of the fluvio-marine strata is not sufficient to admit the presence of the entire thickness of the middle and lower eocene strata between these two limits, even on the supposition that they filled the least possible space they could be made to occupy, which would be when placed vertically.

For example, in Alum Bay, where the strata are fully displayed, and where they have been measured most carefully, in the utmost detail, the entire thickness of the beds between the fluvio-marine series and the chalk is 1,500 feet, rather more than which space is filled by them, as is shown in Section D, Plate 9.

In Section C, distant from Section D scarcely a mile and a quarter, the space in question is but about 1,150 feet, so that, allowing the thickness of the lower tertiaries and the Bagshot sand to remain unchanged, the dis-

appearance of more than 400 feet of strata remains to be accounted for. Beneath the Bagshot sands an inconsiderable thickness of clay intervenes here between a mass of yellow and crimson sands, bearing a strong resemblance to some portions of the sands of the lower Bagshot series, which are succeeded by subordinate beds of white clay similar to the pipeclays of that group. Here then the middle Bagshot beds, comprising the Barton clay and the Bracklesham sands, are, to all appearances, absent, and remain to be accounted for.

Again,—taking an example from the opposite extremity of the island, situated similarly with respect to Whitecliff Bay as the previous locality was in reference to Alum Bay,—the horizontal distance between the base of the lower tertiaries and that of the fluvio-marine series (measured on the map) is reduced to little more than 600 feet, so that in this instance nearly 900 feet of beds have disappeared at the surface, even supposing the thickness of the series in question to be the same as the opposite end of the island, which is not the case, inasmuch as they are more developed eastward than westward.

With regard to the strata between the fluvio-marine series and the chalk, the sections of them in the interior of the island are few and comparatively insignificant.

The Upper Bagshot Sands are seen at their upper junction in a pit about half a mile west of Swainstone, by the side of a road to Fulholding Farm; and again, further east, under similar circumstances, in the lane a short distance south of Great Park Farm.

A good section of the Bagshot sands is displayed in the road to Cranbourn Mill, on the east side of the brook; the beds consisting of pink, white, and pale ochreous-coloured yellow sands. In the road north of the mill yellow and greenish shaly sands, containing quartz grains, are exhibited.

South of Gunvelle, about half a mile north-west of Carisbrook, the Upper Bagshot Sands and Barton Clay occupy a vertical position, in the brick-pits—where the latter contains a few small fossils, and furnishes the brick earth worked there.

In East Medina, the Upper Bagshot sands show themselves near Thornhill Farm, and in a pit at the south-east corner of the wood by the side of the road from Arreton Down to Lynn Farm, where they are pure white glasshouse sands, together with some of a yellow colour. They are here, also, vertical, and rest with a sharp well-defined line (marked by a few small rounded flint pebbles) on green clay—Barton clay in all probability.

A similar section is seen in a pit east of Combley Farm, and again south of Little Nunwell, close to the farmbuildings.

SECTION

From the Base of the Fluvio-marine Series to the Chalk, measured in Alum Bay, by Henry W. Bristow and R. Gibbs.

UPPER BAGSHOT BEDS.

	Ft.	In.
Iron band at the base of the fluvio-marine series		
1. Yellow sand (the thickness at the outcrop is only 6 feet)	11	0
2. White glass-house sand, with a few ferruginous stains of a bright yellow colour about	60	0
3. Fine bright yellow sand, the lower 12 feet white	36	0
4. Ferruginous yellow sand	1	4
5. Yellow sand	14	0
	*122	4

MIDDLE BAGSHOT BEDS.

(*Barton Clay.*†)

6. Ferruginous dark-blue clay, gypsum, fragments of univalve shells, numerous fossils	24	0
7. Pale and ferruginous yellow sandy clay, green in the upper part, *Lignite, Corals, Dentalium, Ostrea, Corbula, Pleurotoma* common and of several species	69	0
(The pathway from the chine to the beach cuts through the lower part of these beds.)		
8. Sands, pale yellowish colour above, green below	35	0
(A layer of septaria occurs in this bed about 10 feet from the top, containing pebbles and fragments of wood, and overlying a band of small flint pebbles.)		
9. Dark bluish-grey and ferruginous-brown sandy clay, containing much gypsum and lignite. Fossils; *Corbula* abundant	53	0
(A layer of septaria, 1 foot thick, occurs 5 feet from the top, 3 feet under which is a band about 2 inches thick of very small pebbles of white quartz, with *Shark's teeth.* A second layer of septaria occurs at 28 feet;		

* Most likely, in their normal state, these sands attain a thickness of from 140 to 200 feet, but it is impossible to ascertain their real thickness in Alum Bay, owing to the disturbed state of the strata there. In this locality fossils have been repeatedly searched for in vain. In Whitecliff Bay, however, the sands under notice furnish ferruginous friable casts of *Cardium, Tellina, Panopæa,* &c.

† In Whitecliff Bay the junction between the ferruginous white beds of the Upper Bagshot and the clays of the Barton series is sharp and well defined. The latter are there represented in the upper part by grey clays, which contain a bed of hard calcareous grit, 8 feet thick, and weathering yellow: *Tellina, Actæon, Nummulites variolarius, Corbula pisum, Pectunculus deletus,* &c. In the lower part clays succeed the above, with a bed of small scattered pebbles, 6 feet thick; *Turritella,* &c., crushed.

	Feet.	In.
and a third, 5 feet from the bottom of the bed. There is also a band of fossils at 13 feet, and a band of lignite 10 feet from the bottom.)		
10. Pale grey loamy sand, mottled with yellow, and thinly laminated - - - - - - - -	9	0
11. Dark bluish-green clay, with numerous univalves and other fossils. A ribbed *Dentalium, Fusus longævus, Voluta spinosa, Solarium, Cardium, Natica* (2 species), *Fusus bulbiformis, Rostellaria, Cancellaria, Pleurotoma, Mitra* (small species)	65	0
12. Greenish-grey sandy clay and sand, ferruginous, and containing carbonaceous matter. A fossiliferous bed of indurated marl, 6 inches thick, occurs 30 feet 6 inches from the top -	45	0
(Lignite bands at 1 foot 3 inches, and 19 feet, and a layer of septaria 28 feet from the upper part.)		
	300	0

(*Bracklesham Beds.**)

13. Conglomerate of rounded flint pebbles, cemented by iron. The pebbles are of various sizes, the largest a foot in diameter - - - - 1 foot to	1	6
14. Sands (principally white), light tawny yellow in the upper part; the lower 3 feet crimson - - - -	45	0
15. Whitish marly clay - - - - - -	25	0
16. Dark chocolate-coloured marls and carbonaceous clay, with much *lignite* and *gypsum* - - - -	39	6

Details of No. 16:—

	Ft.	In.
Clays and marls - - -	15	3
Lignite band - - - -	1	6
Clays and marls - - - -	3	3
Lignite band - - - -	1	3
Clays and marls - - - -	6	0
Lignite band - - - -	2	3
Clays and marls - - - -	4	3
Lignite band - - - 9 inches to	1	0
Clays and marls - - - -	5	0
	39	6

	111	0

* In Whitecliff Bay this group of beds is represented by lignite-clays and green clayey sands, with large *Venericardia* and *Natica*, *Cardita imbricata*, *Nummulites*, &c., beneath which are green clayey sands, containing 6 bands of shells, with *Venericardia planicosta* (of much smaller size than at Bracklesham, and pierced by small boring shells), *Turritella imbricataria*; *Venus*, &c.

LOWER BAGSHOT BEDS.*

	Feet.	In.
17. Very thinly laminated pale yellow sand - - -	10	0
18. White, crimson, and rose-coloured variegated sands passing into pale brownish-yellow sand - - - -	50	0
19. Thinly laminated light-grey pipeclay - - -	1	6
20. Pale yellow sand and white laminated clay, with crimson streaks. Concretions of subsulphate of alumina occur about 55 feet from the bottom of the bed, where the sand is mottled, pink and light yellow colour - - -	104	0

Details of the upper part of No. 20:—

	Ft.	In.
Yellow sand - - - -	14	6
Pipeclay parting - - - -	—	
White sand - - - - -	11	6
Yellow sand - - - -	12	0
White and crimson sand - - -	—	

21. Thinly laminated grey clays, chocolate-coloured in the upper part - - - - - - -	99	0

Details:—

	Ft.	In.
Clays - - - -	27	0
Lignite (very bituminous), with sulphate of iron about 15 feet below it - -	0	6
Clay - - - -	44	0
Thinly laminated yellow sandstone, with much carbonaceous matter, with a band of lignite 5 or 6 feet above - - 4 to	0	6
Clay: white, hard and marly - -	27	0
	99	0

21. Tawny, variegated, pink and white sands, with brown laminæ: White sand predominates - - -	90	0
(Iron bands, 1 inch thick, occur at 52 feet and 79 feet from the bottom.)		

* The Lower Bagshot beds in Whitecliff Bay consist, in the upper part, of thinly laminated light grey pipeclay and yellow sand, with broken leaves, overlying a bed of chocolate-coloured pipeclay, containing much selenite in small long crystals. To these succeed grey clays, also with much selenite in small crystals, and small flattened nodules more sandy and laminated in the upper than in the lower part. Beneath these is a bed 18 inches thick, of rounded black flint pebbles. Light yellow micaceous sands, forming the greater proportion of the Lower Bagshot beds, follow, and rest on a band of iron sandstone, which stretches out at sea. Between the iron sandstone and the London clay are 37 feet of sands, clays, and pipeclay.

	Ft.	In.
23. Pale grey and yellowish brown sands, with thin laminæ of a darker grey clay, containing pyrites and carbonaceous matter. Some of the laminæ, when newly broken, are of a greenish colour. These beds are darker and most laminated in the lower part, and are most sandy towards the top part	60	0
24. Light grey sandy clay, with vegetable matter lying across the bedding	2	0
25. Fawn-coloured and whitish sands, slightly variegated with red	40	0

Details:—

	Feet.	In.
Slightly laminated white sand	9	5
Iron band	0	1
White, pink, and yellow laminated sand, with veins of white pipeclay and bright red laminæ of iron	7	6
Fine light yellow sands	23	0
	40	0

26. Pipeclay (full of leaves) between yellowish-white and variegated laminated clays. The lower 2 inches are composed of sandy white pipeclay, with laminæ of white and crimson sand, which becomes thicker towards the upper part of the cliff	6	0
27. Bright yellow sand, with thin laminæ of clay	13	0
28. Iron band	2	0
29. Yellow and grey sands	15	4
30. Grey laminated sands and clays, chiefly sands	18	0
31. Do. do. very carbonaceous, nearly all clay	11	0
32. Do. do. clay predominating	3	6
33. Iron sandstone band and tawny iron sand, with veins and strings of iron and pebbles of quartz - 6 inches to	3	0
34. Pale yellow and bluish-white sand, darker in the upper part, and with a few laminæ of clay	15	4
35. Blue clay, with thin (¼ inch) sandy laminæ; carbonaceous matter	27	0
36. Grey and yellow sands, with thin laminæ of blue clay; much pyrites and carbonaceous matter (These beds have a reversed dip on the top of the cliff, apparently dipping under the chalk at an angle of 80°.)	61	0
37. Bright yellow and white sands, more laminated and clayey than the bed above, and containing much carbonaceous matter. The lower 5 feet sand	23	0
38. Iron sandstone	3	0

	Ft.	In.
39. Parting of pale clay of variable thickness	0	2
40. Very thinly laminated white and yellow sand	1	10
41. White sand and blue clay, becoming more clayey towards the lower part	5	0
	661	2

LONDON CLAY.*

	Ft.	In.
42. Dark blue clay, resting on	1	0
43. Flattened nodules of argillaceous ironstone	0	1
44. Laminated dark blue clays and sands, in equal proportions	1	8
45. Band of argillaceous ironstone, with carbonaceous specks, and coated with iron sand	0	1½
46. Sands and clays as before, becoming more sandy	1	6
47. Band of thinly disseminated nodules of argillaceous ironstone	0	1
48. Brown and dark blue clayey sands	0	6
49. Band of argillaceous ironstone	0	2
50. Thinly laminated sand and clay	0	10
51. Band of argillaceous ironstone	0	3
52. Grey clayey sands	23	0
53. Band of small black pebbles		
54. Bluish-green clayey sand, with 3 bands of scattered nodules of argillaceous ironstone	7	7
55. Band of scattered nodules of argillaceous ironstone	0	2
56. Dark greenish irony sand	2	0
57. Scattered nodules of argillaceous ironstone	1	0
58. Dark sandy clay	5	0
59. Scattered nodules of variable thickness	0	6
60. Brown marly sand and sandy clay, and dark greenish sand, with septaria (crustacean remains), nodules of iron pyrites, and irregular concretions of argillaceous ironstone, containing black and green specks and small rounded grains of quartz	175	0
(The dip of these beds is vertical, or 3° the reversed way.)		
	199	8½

* The junction between the Lower Bagshot beds and the London clay is well exhibited in Whitecliff Bay, the former being light grey sands weathering nearly white, with occasional thin laminæ of pipeclay, and the former ferruginous brown clay. Beneath these upper clays are laminated clays and sands, resting on clayey sand, with sandy alternations and laminæ, and a layer of large septaria (*Pinna affinis*). To these succeed dark clayey sand or sandy clay, with *Panopæa intermedia* lying in their natural positions, then ferruginous brown sands, and in the lower part dark grey clayey sands, weathering brown and less dark, hard, and clayey than the beds above ; *Lignite.*

PLASTIC CLAY.*

	Ft.	In.
61. Red and white mottled clay, with a ferruginous parting at 4 feet	25	0
62. Ferruginous-brown clayey sand	14	0
63. Bright red and white mottled clay (pipeclay)	20	0
64. Brown and grey sandy clay (with a bed towards the middle of dark red clay 3 feet thick), most sandy in the upper 5 feet	10	0
65. Tenacious, wet, red and white mottled clay	3	0
66. Tenacious blue and brown ferruginous clay	8	0
67. Brown sand covering an uneven eroded surface of chalk	3 to 4	0
	84	0

CHALK.

The chalk near its junction with the Plastic clay is hard, and traversed by beds of flint, some of which are of large dimensions. The surface of the chalk is eroded and uneven, and between it and the Plastic clay there is a slight unconformability. The irregularities in the upper surface of the chalk are filled with fine fawn-coloured sand, inclosing small rounded pebbles of flint, and becoming darker and more ferruginous, and of a rufous-brown colour, passing upwards into red and green mottled clay. Water is thrown out by the upper surface of the chalk.

Table of Thicknesses of Strata in the Isle of Wight.

		Ft.	In.
Hempstead Series,	Corbula (upper beds)	15	0
„	Upper freshwater and estuary marls	40	0
„	Middle freshwater and estuary marls	50	0
„	Lower freshwater and estuary marls	65	0
Total thickness of the Hempstead freshwater and estuary marls		155	0
„	„ series	170	0
Bembridge marls beneath Hempstead cliff		68	0
„	at Whitecliff Bay	91	0
„	limestone at Headon Hill	25	0
„	„ at Sconce	22	0
„	„ Whitecliff Bay	24	6

* The junction with the London clay is sharp and well defined in Whitecliff Bay. Between the ferruginous sandy clay of the London clay and the red mottled clay of the Plastic clay there is a band of scattered pebbles, representing the basement bed of the London clay of Mr. Prestwich.

	Ft.	In.
Total thickness of the Bembridge series at Whitecliff Bay	115	6
„ Upper eocene strata - 263 ft. to	285	0
Osborne series at Headon Hill	50	0
„ Tollands and Colwell Bays	62	0
„ St. Helen's	67	0
„ Whitecliff Bay	79	6
Upper Headon beds at Headon Hill	85	0
„ Tollands and Colwell Bays	49	0
„ Whitecliff Bay	44	0
Middle Headon beds at Headon Hill	30	0
„ Tollands and Colwell Bays	23	0
„ Whitecliff Bay	100	0
Lower Headon beds at Headon Hill	67	6
„ Tollands and Colwell Bays	81	0
„ Whitecliff Bay	31	0
Total thickness of Headon beds at Headon Hill	182	6
„ „ Tollands and Colwell Bays	153	0
„ „ Whitecliff Bay	175	0
„ fluvio-marine strata of the Isle of Wight 500 ft. to	560	0
Upper Bagshot beds at Alum Bay - 140 ft. to	200	0
„ at Whitecliff Bay	200	0
Barton clay	300	0
Bracklesham beds	111	0
Middle Bagshot beds	410	0
Lower Baghot sands and clays	661	2
Total thickness of the Bagshot series	1271	2
„ middle eocene strata (I. W.) 1770 ft. to	1830	0
London clay at Alum Bay	199	8
„ Whitecliff Bay	295	0
Plastic clay at Alum Bay	84	0
„ Whitecliff Bay	163	0
Total thickness of the lower eocene strata at Alum Bay	283	8
„ „ Whitecliff Bay	458	0
„ tertiary strata of the I. of W. 2030 ft. to	2290	0
Chalk		
*Upper green sand (Compton Bay)	130	0
*Gault („)	100	0
Wealden (blue beds in Compton Bay)	150	0
„ („ Brixton Bay)	212	6

* Measured 25th September, 1852, by H. W. Bristow and Richard Gibbs, of the Geological Survey.

Economics.

Alum Bay has long been celebrated for the pure white *glass-house sand* which is obtained there from the Headon sands. Mr. Squire, who has rented the cliffs for several years, states, that, in the six years between 1850 and 1855, 21,984 tons were shipped from Yarmouth, principally to London and Bristol.

The *clay ironstone*, which is found in considerable quantities lying loose upon the shore at the foot of the cliffs between Yarmouth and Hempstead ledge, is collected on the beach and sent to Swansea, where it is smelted into iron.

Cement stones are obtained to a small extent from Alum Bay, but the greatest supply is now derived from the opposite coast of Hampshire, where the septariæ, which once formed a portion of the Barton beds, are procured by dredging.

With regard to *building stones*, the greater part of the Limnæan limestone used is obtained from the quarries at Binsted, and from the blocks lying scattered along many parts of the sea shore. The sandstone forming the upper part of the upper green sand is used to a small extent, and the coarse ferruginous grits and sandstones of the lower green sand still more sparingly. Some of the beds of the lower chalk are so dense as to ring under a blow of the hammer, and are sufficiently hard for building purposes, especially when protected from the weather. A portion of the inner walls of Brixton Church has been built of chalk.

Pipeclay.—The white pipeclay of the Lower Bagshot beds, which is so largely developed in Dorsetshire, almost entirely disappears in the Isle of Wight, being there replaced by sands. In Alum Bay the clay is represented by a bed only 6 feet thick but it still retains its usual characters, and is marked by the presence of leaves of plants, resembling those which are found associated with the corresponding clays of Dorsetshire.

Between Alum Bay and Freshwater Gate the pipeclay has been dug many years ago, and traces of the old workings are still visible.

At Newport coarse *pottery* is manufactured from the red clays of the plastic clay.

Bricks are made from the clays of nearly all the tertiary strata. At Ninham the loam overlying the flint gravel is converted into bricks. At the brickpits, north of Arreton Down, the brickearth is derived from a red mottled loamy clay, containing a few small flints, and much resembling plastic clay, except that it is of a lighter colour. About 12 feet of the loam rests upon 3 feet of flint pebble gravel, which forms the base of the high-level gravel there.

The Bembridge marls are converted into bricks near Ningwood. Between Claybrook and Heathfield green clays, forming a part of the Osborne beds, are employed for the purpose; and at Little Apley, near Ryde, the red and green clays of the same series.

At Gunvelle, near Newport, the Barton clay is made into bricks; and at Ningwood the Bembridge marls are converted both into bricks and tiles.

At Newport, tiles are manufactured from the red clays of the Plastic clay, while bricks are made from the London clay immediately above.

Alum was formerly manufactured in the island from the clays of Alum Bay, and as early as 1579 at works in Parkhurst Forest.

Salt is made in small quantities at the Salterns, near Newtown, by the evaporation of the sea water; first, by exposing it in shallow pits to the combined influence of the sun and wind, and then boiling the strong brine till salt is formed.

Agates, and other small stones fit for polishing, are collected on the beach, especially near Sandown, as well as flint pebbles which have been derived from the chalk.

H. W. BRISTOW.

Descriptions of the Plates of Fossils, by John Morris, F.G.S., &c.

PLATE 1.

Hempstead Series.

Corbula pisum. Sow.—Plate 1, fig. 1.

Corbula pisum. Sow. Min. Con. tab. 209, fig. 4.

Corbula pisum. Nyst, Coq. Foss. de la Belgique. tab. 3, fig. 4.

This form is allied to some varieties of Corbula rugosa.

Localities.—The species has a wide distribution both in space and time; it occurs in the lower eocene clay of Hampstead and Highgate, in the middle eocene of Barton and Bracklesham, and in the Upper Hempstead series, and also, according to Nyst, in many localities of the Limburg series in Belgium. It is also found in the Mayence Basin (Sandberger) at Magdeburg and in the environs of Paris.

Corbula Vectensis. Forbes.—Plate 1, fig. 2.

? Corbula nitida, Sow. Min. Con. t. 362. f. 1—3.

C. testâ transversâ, ovali, pellucidâ, lævi, subæquilaterâ, posticè obtusè angulatâ, attenuatâ, truncatâ; anticè rotundatâ, margine basali arcuato: sinu palleali sub-trigono, parvo.

A small transversely oval shell, smooth and somewhat equilateral, with the anterior margin rounded and the posterior one obtusely truncate and attenuate; the ventral margin curved.

Locality.—From the Upper Hempstead beds; the specimen figured is silicified, a condition in which specimens of other species frequently occur at this locality.

Cyrena semistriata, Desh. *var.*—Plate 1, fig. 3.

Locality.—The Upper Hempstead series. (See page 46.)

Cytherea (Venus) Lyellii. Forbes.—Plate 1, fig. 4.

V. testâ trigonâ, convexâ, lævi, posticè subproductâ truncatâ, anticè rotundatâ; margine ventrali arcuatâ; umbonibus incurvis, lunulâ cordatâ, magnâ, sinu palleali sub-trigono, lato, brevi; cardine tridentato, dente antico compresso, dente cardinali bifido.

A convex and somewhat trigonal shell, with a rather large cordate lunule; the anterior margin is rounded and the posterior one somewhat produced and truncate; in larger specimens than the one figured, and which have also been obtained by Mr. Edwards from Hempstead Cliff, this latter character is not so distinct.

Locality.—This species occurs in the Upper Hempstead series; the specimen figured is silicified.

Ostrea callifera. Lam.—Plate 1, fig. 5, 5*a*.

Ostrea callifera. (Lam.) Desh. Coq. Foss. Tab. 51, figs. 1, 2.

Ostrea callifera. Goldfuss Petref. p. 27. Tab. 83, fig. 2.

Ostrea callifera. Nyst, Coq. Foss. de la Belgique, tab. 29, fig. 1.

O. testâ ovatâ, rotundatâ, valvâ majore crassissimâ, intus irregulariter excavatâ, extus concentricè rugosâ; areâ ligamenti latâ, curvatâ.

This species is sometimes very massive; it is of an oval oblong form, with short triangular and slightly recurved beaks; the ligamental area is broad and flat; the cavity of the inferior valve is large, deep, and slightly prolonged below the beaks; the outer surface is irregularly rugose, the lamellæ being closer together and more numerous on the superior valve, which is flat, and much less thick than the other.

This species, originally considered by Lamarck as identical with the recent *Ostrea hippopus*, is very characteristic of the upper eocene deposits.

Localities.—This species, formerly considered peculiar to the environs of Paris, where it occurs in the marls superior to the gypsum, in the environs of Versailles and near Longjumeau, was discovered by Professor E. Forbes, in the Upper Hempstead deposits of the Isle of Wight. It has been recognised by Dr. Sandberger in the marine sand and Cyrena marls of the Mayence Basin, and has been noticed by M. Nyst as occurring at Piétrebais in Belgium.

Natica labellata. Lam.—Plate 1. fig. 6.

Natica labellata. (Lam.) Desh. Coq. Foss. tab. 20, fig. 3, 4.

Locality.—In the Upper Hempstead series. This species also occurs in the lower eocene of Bognor and Highgate; in the middle eocene of Barton and Bracklesham. In France it is found in the calcaire grossier, gres marin inferieur, and gres marin superieur.

Cerithium plicatum. Lam.—Plate 1, fig. 7.

Var. *Cerithium subcostellatum.* Forbes, MSS.

This form, which is referred to in the text as C. subcostellatum, Forbes, is probably only a variety of C. plicatum, Lam. (Plate 2, fig. 11), in which, in the later volutions, the costæ are only continued halfway down the whorls, and the lower transverse bands are simple. Some of the shells referred to this form appear to be identical with the *Cer. Galeotti* of Nyst.

Locality.—This variety is tolerably abundant in the Upper Hempstead series.

PLATE 2.

Hempstead Series.

Cyrena semistriata. Desh.—Plate 2, fig. 1, 2.

These figures illustrate some other varieties of the *Cyrena semistriata,* Desh., which is described in page 148, and figured in plate 3, fig. 2.

The species occurs both in the Bembridge and Hempstead series, and is very abundant in the latter deposits at Hempstead Cliff, where many of the specimens occur perfectly silicified.

Cyclas Bristovii. Forbes.—Plate 2, fig. 3.

C. testâ subquadratâ, ventricosâ, anticè attenuatâ rotundatâ, posticè truncatâ, lineis incrementi concentricè striatâ.

A small somewhat quadrate and rather ventricose shell, the anterior margin rounded, and the posterior truncated. The surface is concentrically marked by the fine lines of growth. This species presents considerable resemblance to a form from Headon Hill, in Mr. Edwards's collection.

Locality.—In the clays at Hempstead cliff.

Mya (Panopæa) minor, *var.* Forbes.—Plate 2, fig. 4.

A description of this species is given at page 149.

Locality.—In the Hempstead series, in greenish shelly marls.

This form, which is believed to be the same as that found in the Bembridge marls, occurs rather abundantly in some parts of the 'White band' in the low cliff on Hempstead shore. It occurs sometimes horizontally disposed in tabular ironstone, at other times it is found in a vertical position partly imbedded in the shelly band and partly in the green clays below, p. 111, the valves generally filled with the shelly matrix. The occurrence of these shells in this apparently normal condition would seem to indicate a quiet deposition of the stratum, and that it had not been subsequently much disturbed. In one of the accompanying bands bivalve shells (Cyrenæ?) are found retaining about ten radiating stripes of darker tint than the other parts of the surface.

Modiola Prestwichii. Morris.—Plate 2, fig. 5. (M. Nystiana, Forbes, on the plate.)

M. testâ ovato-elongatâ, angustâ, subdepressâ, supernè dilatatâ, longitudinaliter striatâ; striis numerosis obscuris: margine crenulato?

An ovate elongate shell of somewhat spathulate form, marked with numerous radiating, but rather obscure striæ.

Locality.—This species occurs imbedded in a clay at Hempstead cliff, containing numerous specimens of Hydrobia and Cyrena.

Unio Gibbsii. Forbes.—Plate 2, fig. 6.

U. testâ elongato-ovatâ, transversâ, utrâque extremitate obtusâ sed posticè obscurè angulatâ; margine ventrali subrecto.

An ovate elongate or somewhat quadrate shell, with the anterior extremity rather more rounded than the posterior, which is slightly angulated and truncated.

The specimen figured has undergone some compression, which has partially modified the original form. It was considered and therefore figured as a distinct species by Prof. E. Forbes; it is, however, closely allied to and difficult to distinguish from some varieties of the *Unio Solandri*, Sow.

Locality.—In dark green clays with Paludina lenta, at Hempstead cliff, and also in the black band at the base of this series.

Unio Austenii. Forbes.—Plate 2, fig. 7.

U. testâ oblongâ, ovali, modioliformi, posticè obtusè rotundatâ, margine dorsali leviter arcuato; margine ventrali subrecto; umbonibus fere terminalibus.

An oblong, depressed, modioliform shell, somewhat expanded and rounded posteriorly; the umbones are depressed and nearly terminal; the surface is but obscurely striated.

Locality.—In the Hempstead series.

Melania inflata. Morris.—Plate 2, fig. 8.

M. testâ conicâ, obscurè costatâ, concentricè sulcatâ, granulatâ; anfractibus (7–8) ventricosis, convexiusculis, suturis profundis, marginibus crenulatis; ultimo anfractu inflato: aperturâ semilunari vel ovatâ.

A small conical shell, with ventricose volutions, concentrically but obscurely granulated, and crenulated at the sutures; the last whorl is the most ventricose.

Locality.—From Hempstead Cliff. This species is subject to much variation; a shorter variety and also a more produced form are in the collection of Mr. Edwards, who obtained them from Hempstead Cliff.

Melania inflata, *var.*, lævis.—Plate 2, fig. 9.

This form is a smaller and smoother variety of the preceding species, and without the marginal crenulations.

Locality.—Occurs with the last at Hempstead.

Cerithium elegans. Desh.—Plate 2, fig. 10.

Potamides margaritaceus. Sow. Min. Con. Tab. 339, fig. 4.

? *Cerithium elegans.* Desh.—Lyell, Manual of Geology, 1855, p. 194.

Locality.—This species is described in the Mineral Conchology, vol. 4, p. 51 as having been brought by Professor Sedgwick from the upper marine formation of the Isle of Wight; but in the Woodwardian Collection at Cambridge it is recorded as having been found at Hempstead Cliff.

Cerithium plicatum. Lam.—Plate 2, fig. 11.

Cerithium plicatum. Desh. Coq. Foss. Tab. 55, figs. 5–9.

Potamides? plicatum, Sow. Min. Con. t. 340, f. 2.

Locality.—A very abundant species in some of the upper beds of the Hempstead series.

Cerithium Sedgwicki. Morris.—Plate 2, fig. 12.

C. testâ elongatâ, subconicâ; anfractibus numerosis (10–12) convexiusculis rotundatis, transversim striatis, ad suturam marginatis; striis (5) decussatis: aperturâ subquadratâ; columellâ biplicatâ.

An elongate somewhat conical shell, with numerous slightly convex volutions, which are transversely striated; the upper margin of the volutions presents a raised crenulated border. The aperture is transverse and somewhat quadrate; the columella in the adult specimens obscurely biplicated.

Locality.—From the white band of the Hempstead series.

Cerithium inornatum. Morris.—Plate 2, fig. 13.

C. testâ elongatâ, subulatâ; anfractibus (9–11) convexis, transversim striatis; striis inequalibus, alternis majoribus, posticis granulatis, striis intermediis tenuibus; aperturâ rotundato-ovatâ, anticè canali brevi exeunti.

This species closely resembles the Cerithium Sedgwicki, but is distinguished by the deeper and more convex whorls, and the more numerous and unequal striæ, as well as by the denticulated character of the two posterior striæ. The aperture is also more ovate and not so transverse, and the specimens examined do not present any folds on the columella.

Locality.—In the white band of the Hempstead series.

Melania muricata. Wood. *var.* costata. Morris, (Sow. sp.)—Plate 2, fig. 14.

Locality.—From the Hempstead Series.

Fusus Edwardsii. Morris.—Plate 2, fig. 15.

F. testâ fusiformi, parvâ, costatâ, concentricè obsoletè sulcatâ; spirâ productâ, anfractibus (7) subconvexis, marginatis; costis undosis, rotundatis: aperturâ oblongo-ovatâ, anticè coarctatâ.

This is a small, neat, and distinct species, of a fusiform shape, with a produced spire; the volutions are ornamented with rounded flexuous costæ, crossed by slight and concentric furrows, which are more distant near the base of the last volution. The aperture is ovate and contracted, and produced anteriorly.

Locality.—In the upper Hempstead series.

Rissoa Chastelii. Nyst, sp.—See plate 4, fig. 3.

Abundant in the Hempstead series.

PLATE 3.

Bembridge Series.

Cyrena pulchra. Sow.—Plate 3, fig. 1.

Cyclas pulcher. Sow. Min. Conch. Tab. 527, fig. 1.

Shell suborbicular, convex, smooth, slender; posteriorly truncated; one sharp-edged and two bifid teeth near the beaks in each valve; lateral teeth plain, obtuse. —(Sowerby.)

The original specimens, which are illustrated and described in the "Mineral Conchology," were first obtained by Professor Sedgwick, who found them "in "abundance on the shore opposite Hempstead Cliff, in a stiff clay, accompanied "by a small *Cyclas*, a striated *Mytilus*, *Potamides ventricosus*, *Melanopsis cari-* "*nata*, several small univalves, and a Serpula."

Specimens of this species, as well as a good series of the other shells obtained from Hempstead Cliff, are in the valuable collection of the Woodwardian Museum at Cambridge. These shells were collected by Professor Sedgwick in 1821, to whom we were first indebted for a notice of the fossils and strata of this interesting locality, which was published by him in the "Annals of Philosophy," for May 1822.

Locality.—Imbedded in green marl of the Bembridge series.

Cyrena semistriata. Desh.—Plate 3, fig. 2.

Cyrena semistriata. Desh. 1830. Enc. Meth. Vers. ii., p. 52.
Cyrena semistriata. Nyst, Coq. Foss. de Belgique, tab. 7, f. 3.
Cyrena cuneiformis. Goldf. Petref., p. 227, tab. 146, f. 2, 3.
Cyrena subarata. F. Sandberger, Mainzer Tertiarbecken, p. 65.
Cyrena subarata. Bronn, Lethæa Geognostica, p. 958, tab. 38, fig. 2 *a—c.*
Venulites subaratus, Schlot. Petref. 1, p. 200.

C. testâ crassâ, ovato-trigonâ, vel cuneiformi, obliquè cordatâ, inæquilaterâ, posticè angulatâ, anticè irregulariter striatâ; striis transversis imbricatis, conspicuis, posticè obsoletis; cardine bidentato, dentibus lateralibus brevibus levigatis.

A thick trigonal or cuneiform shell, gibbose and inequilateral, with prominent umbones, and presenting on the anterior side, numerous transverse, prominent ridges, which are less conspicuous towards the middle of the shell, and become obsolete on the posterior portion. In well-preserved specimens five to seven longitudinal rays or bands of colour may be observed on the surface.

This species presents considerable differences in form even in the same locality, the shell in some cases being much more produced posteriorly; in others more ovately triangular. Some specimens are larger than that figured, and than those illustrated by Nyst and Goldfuss, the latter author having described as distinct species what are probably only varieties of this form (*Cyr. cuneiformis, C. trigona, C. æqualis*).

The species presents considerable analogy with Cyrena cuneiformis, Fer., to which it has been frequently referred; but it is readily distinguished by the shorter and more conical form of the lateral teeth, and the frequent absence of striæ on their sides, especially on the posterior tooth.

Localities.—This shell is widely distributed and also very abundant in the localities where it is found. It is characteristic of the upper eocene strata, and occurs in the Bembridge marls and Hempstead series. It is found in many localities in Belgium, as at Kleyn-Spawen, &c., in Limbourg and in Brabant, and is very common in the Mayence basin, to a stratum of which (the Cyrenen-mergel of Sandberger) it gives the name.

Professor Sedgwick collected the species in 1821 at Hempstead Cliff, and fine specimens of it are in the Woodwardian Museum; it has sometimes been referred to from that locality as Cyrena cuneiformis (Sow.), a fossil species belonging to the Lower eocene or Woolwich strata.

Mya (Panopæa) minor. Forbes.—Plate 3, fig. 3.

Shell transverse, compressed, elongately ovate, very inæquilateral; the anterior side narrow, the posterior side slightly dilated, the surface corrugated by lines of growth, giving it an obscurely sulcated appearance. The anterior is about one-third as long as the posterior portion, and the width about one-half the length. The umbones are nearer the anterior margin than in P. intermedia (Sow.), and the surface is less corrugated than in P. corrugata or even P. intermedia.

Localities.—Bembridge and Hempstead.

Cyrena obtusa. Forbes.—Plate 3, fig. 4, 4 *a*, *b*.

C. testâ lævi, convexâ, subtrigonâ, margine antico vix producto, margine postico angulato, sub-producto; margine ventrali rotundato.

A somewhat convex and trigonal shell, smooth or faintly marked by the lines of growth, with the anterior margin slightly produced, the posterior margin rather angulated and produced; the ventral margin very slightly rounded. Umbones generally eroded. Two bifid teeth on the left valve; the anterior and posterior lateral teeth lamellar, short and crenated. This shell is less gibbose and triangular than *C. trigonula*, and is less ventricose about the umbones, and a more depressed shell, than *C. obovata* (Sow.).

Locality.—In the Bembridge Marls, at the east end of Hempstead Cliff, and also at Lyndhurst, Hants (Mr. Edwards's collection). Also at Hordwell.

Nucula similis. Sow.—Plate 3, fig. 5.

Nucula similis. Sow. Min. Con. Tab. 192, figs. 3, 4.

This shell more nearly resembles the form from High Cliff, Hampshire, than that from the Barton beds.

Locality.—Bembridge marls.

Cyrena transversa. Forbes.—Plate 3, fig. 6.

C. testâ transversâ, depressâ, angustâ inæquilaterâ, lævi, posticè productâ, truncatâ, anticè attenuatâ rotundatâ; margine ventrali leviter arcuato.

A transverse smooth depressed shell, inæquilateral, the anterior margin attenuate and rounded, the posterior produced and truncate; the ventral margin slightly arcuate.

Locality.—In grey shelly marls at Hempstead Cliff, belonging to the Bembridge series.

Mytilus affinis. Sow.—Plate 3, fig. 7.

Mytilus affinis. Sow. Min., Con. Tab. 532, fig. 1.

Locality.—Imbedded in green sandy and shelly marls of the Bembridge series.

Arca Websteri. Forbes.—Plate 3, fig. 8.

A. testâ parvâ, ovato-oblongâ, modioliformi, transversim sulcatâ radiatim striatâ, anticè angustiori, posticè latiori effusâ, subcarinatâ; striis posticis elevatis, acutis; striis cæteris obscuris; carinâ rotundatâ: cardine interrupto, dentibus prominentibus, distantibus.

A small depressed modioliform shell, transversely sulcated, and with radiating striæ; the anterior narrow, the posterior part spread out and somewhat carinate. The posterior striæ are elevated, and acute.

The umbones are placed near the anterior margin, and the middle part of the cardinal area is without teeth. The teeth are prominent and distant.

Locality.—From the Bembridge series.

Ostrea Vectensis. Forbes.—Plate 3, fig. 9, 9 *a*, *b*.

O. testâ ovato-trigonâ oblongâ, attenuatâ, subangustâ; areâ cardinali fossulâ triangulari, latâ, recurvâ exaratâ; umbonibus obtusis: valvâ superiori lineis incrementi numerosis ornatâ; valvâ majore crassâ, extus rugosâ.

An oblong and rather narrow shell, with the larger valve somewhat thick and externally rugose; the upper valve flat, thin, recurved at the umbo, and marked by numerous concentric lines of growth. Ligamental area broad and triangular.

Locality.—In the sandy beds of the Bembridge series.

Cytherea incrassata. Sow.—Cast of, Plate 3, fig. 10.

Locality.—From the Bembridge series.

Cerithium Austeni. Morris.—Plate 3, fig. 11.

C. testâ elongatâ, turritâ, subulatâ; anfractibus numerosis, tricarinatis, ad suturam canaliculatis; carinis subæqualibus, carinâ posteriori majori, granis confertis compressis ornatâ: aperturâ subquadratâ, basi transversim lineatâ.

An elongated turreted shell, with numerous volutions, ornamented with three rows of closely set tubercles, of which the posterior series are larger, the tubercles of this row being longitudinally compressed or drawn out like a comma. Aperture somewhat square.

Locality.—The figured specimen of this elegant shell was obtained by Professor Forbes in the Bembridge marls of Hempstead Point, Isle of Wight, but numerous specimens are in the collection of Mr. Edwards, who obtained them from Hempstead Cliff. It is closely allied to C. conjunctum and C. trochleare.

Cerithium mutabile. Desh., *var.?*—Plate 3, fig. 12.

This form is considered to be only a more rugose variety of the *Cerithium mutabile?* described in plate 4, fig. 6, from which it differs in the shape and scattered character of the posterior tubercles and the less ornamented surface. It so closely resembles some varieties of *C. variabile*, that, notwithstanding the difference of its position in the geologic series, it is difficult to distinguish it from that species.

Locality.—In the Bembridge series.

Cerithium margaritaceum. Sow., *var.*—Plate 3, fig. 13.

A comparison of this shell with a series of specimens in Mr. Edwards's cabinet, suggests that it is probably only a variety of the form represented in Plate 2, fig. 10, and there referred to the C. elegans, (C. margaritaceum, Sow.) The specimen is much worn and broken, but the line of the suture in the figure is made more decurrent than in the original specimen, and consequently the aperture is represented as being more ovata then it is in fact, and not so transverse.

Locality.—This form occurs at Hempstead cliff, but is not very abundant.

Melania turritissima. Forbes.—Plate 3, fig. 14.

Melania turritissima. Lyell, Manual of Geology, 1855, p. 209.

? *Melania subulaspira.* Wood, London Geol. Journ. 1, p. 118.

M. testâ conicâ, prælongâ, anfractibus (9–11), subconvexis, anticè angulatis; aperturâ ovatâ, posticè contractâ, anticè effusâ.

An elongate conical shell with numerous slightly convex volutions, which are angulated anteriorly. The aperture is ovate, and the inner lip is slightly reflected and elevated. The species appears to be closely allied to the shell named by Mr. S. Wood *Melania subulaspira*, from the fresh-water series of Hordwell Cliff.

Locality.—This is a very abundant species, and occurs both in the Bembridge and Hempstead series, some of the layers being consolidated by pyritic matter; also in the upper fresh-water beds at Hordwell, containing the *Alligator Hantoniensis*, Wood.

Melania Forbesii. Morris.—Plate 3, fig. 15.

M. testâ conicâ elongatâ, anfractibus (8-10), subventricosis, aperturâ ovatâ, posticè attenuatâ.

A conical elongate shell, with about eight or ten somewhat ventricose volutions.

The absence of angularity on the anterior portion of the volutions, and the less number of whorls, distinguish this form from the preceding (*M. turritissima*).

Locality.—An abundant form in the green marls of the Bembridge series.

Melania muricata. S. Wood.—Plate 3, fig. 16.

Melania muricata. Wood, Lond. Geol. Journ., vol. 1, p. 3.
M. echinata. Forbes MS.

M. testâ turritâ, acuminatâ, costatâ, transversim lineatâ: anfractibus subplanis, muricatis, decussatis, semicostatis; anfractu ultimo anticè lineato, lineis elevatis, acutis: aperturâ ovali.

A small turreted shell, with rather flat volutions, which are transversely and longitudinally striated, forming granulations at the intersections; the suture is angular and the aperture somewhat oval.

This is a variable species, abundant in some localities and of which the next described form is probably only a variety.

Localities.—In the Bembridge series. It occurs also at Headon Hill with *Bulimus politus*, and in the upper marine at Colwell Bay, and also at Hordwell.

Melania muricata, *var.* excavata.—Plate 3, fig. 17.

This shell is apparently an elegant variety of the last species; it is more elongated, the costæ are less prominent, the extreme upper and lower transverse lines being most defined, the intermediate one being less developed or sometimes obsolete. The volutions are also flatter, or even concave, and the suture more distinct.

Locality.—In the Bembridge series, very abundant, imbedded in shelly green marls.

PLATE 4.

Headon Series.

Scalaria lævis. Morris.—Plate 4, fig. 1.

S. testâ turritâ, anfractibus rotundatis, costatis; costis lamellosis; lamellis, supernè complanatis sub-duplicatis, interstitiis lævibus: aperturâ sub-effusâ.

Shell turreted, volutions rounded, costated, costæ lamellar, slightly divided on the upper surface which is flat or depressed; the interstitial spaces smooth. Aperture somewhat effuse, its length 3½ lines.

The *Scalaria lævis* resembles in general form the *S. acuta*, Sow., but in that species the volutions are more tabulated, the whorls transversely striated, and the lamellæ more continuous.

The smoothness of the interstitial spaces, which has suggested the name, is not a very common character in the other species of Scalaria from the tertiary series.

Locality.—From the Headon Hill series. At Colwell Bay about 8 lines long, and also at Hordwell, Hampshire; specimens from both localities are in the collection of Mr. Edwards.

Cerithium ventricosum. Sow.—Plate 4, f. 2.

Potamides ventricosus. Sow. Min. Conch. t. 341, f. 1. non *C. ventricosum*, Desh.

"Conical, turreted; whorls ventricose, costated, transversely striated; striæ two or three upon each whorl, most elevated upon the costæ, aperture orbicular, with an extremely short beak."—Sow.

The specimens figured can scarcely be considered a variety of this very abundant and gregarious species; slight variations may be perceived when a large number of specimens are compared, but these are not sufficient to characterize it as a distinct form.

Locality.—Very abundant at Headon Hill. It occurs also at Colwell Bay, and at Hordwell and Long Mead End.

Rissoa Chastelii. ? Nyst, sp.—Plate 4, fig. 3 (*Hydrobia*, on plate).

Paludina Chastellii. Nyst. Coq. Fos. de la Belgique. Plate 37, figs. 9–11.

The specimen figured shows an aperture more effuse than is usual in the forms of this species, but not to so great an extent as in that represented by Nyst in his Tab. 37, fig. 11.

In some specimens the aperture is distinctly separated from the body whorl.

Locality.—The specimen figured is stated to be from Headon Hill, but this species is characteristic of and abundant in some beds of the Hempstead series, to which it had hitherto been considered as confined. It occurs in the Limburg series of Belgium, which are the equivalents of the Hempstead beds of the Isle of Wight.

Nematura parvula. Desh. sp. (?)—Plate 4, fig. 4.

Paludina parvula. Desh. MS.

Testâ minimâ, conoideâ, acuminatâ, lævi; anfractibus sex, convexiusculis, suturâ distinctâ; aperturâ rotundatâ, ovali; posticè angustatâ.

A small conical and smooth shell, with five to six slightly convex volutions, separated by a conspicuous suture; the aperture is nearly round and slightly contracted posteriorly.

Locality.—An abundant form in the upper marine of Colwell Bay, and also in the estuary bed at Long Mead End forming the transition bed between the upper beds of the true marine deposit of Barton Cliff and the fluviatile series.*

Melania per-acuminata. Charlesworth.—Plate 4, Fig. 5.

Ibid. Illustrations of minute fossil shells.

M. testâ elongatâ, anfractibus lævibus, anticè subcarinatis; suturâ vix depressâ; aperturâ subovali, posticè angustâ.

Shell elongate, volutions smooth, anteriorly subcarinate or flatly convex, suture not much depressed; the last volution presents a subangular form. Aperture somewhat ovate and narrow posteriorly.

The specimens figured are considered to belong to the same forms as those illustrated by Mr. Charlesworth, but the aperture and body whorl are more elongate.

Locality.—In the Headon series.

This species also occurs in the fresh-water beds at Hordwell, where it is very abundant. (Mr. Edwards's collection.)

Cerithium mutabile. Desh. *var.* ?—Plate 4, Fig. 6.

The identity of this shell with *C. mutabile*, to which it was referred by Professor Forbes, is rather questionable. The specimen figured, and the variety represented by Fig. 12. Plate 3, more especially the latter, closely resemble some forms of *C. variabile*, a species from the Lignite beds (*Argile plastique*). They are probably the same as the shell represented as C. funatum in the Mineral Conchology, Table 128, Fig. 2.

Locality.—In the Headon series; and also in the upper marine at Colwell Bay; and in the fresh-water deposit (crocodile bed) at Hordwell, Hampshire.

* See Mr. Edwards's "Memoir on Tellina," in the London Geological Journal, vol. i. p. 107.

Cerithium pseudo-cinctum. D'Orb.—Plate 4, Fig. 7.

Potamides cinctus. Sow. Min. Conch. Tab. 340, Fig. 1. *Non* Cerithium cinctum, Lam.

C. testâ elongato-conicâ, acuminatâ; anfractibus subconvexis, transversim tricinctis, cingulis regulariter granulosis, inæqualibus; suturâ canaliculatâ: aperturâ subquadratâ, anticè productâ; columellâ uniplicatâ, recurvâ.

Shell elongate, conical; volutions flatly convex, depressed on the posterior margins, each volution presenting three nearly equi-distant rows of granules, those on the posterior row being somewhat the largest and transversely flattened, lower volutions varicose; suture channelled: aperture anteriorly produced, with one fold on the columella which is recurved.

This form differs from the *C. cinctum* in the number, character, and prominence of the granulations. In the French specimens the granules are more numerous and rounder, and the first and third rows are the largest. In the English specimens the rows diminish gradually, and in the adult shell, the anterior row and sometimes the second are smooth.

Localities.—In the estuary beds of Headon Hill, Colwell Bay, Hordwell, belonging to the Headon series.

Cerithium trizonatum. Morris.—Plate 4, fig. 8.

Compare Cerithium inornatum. Plate 2, fig. 13.

C. testâ elongato-conicâ, anfractibus convexiusculis, transversim cinctis: aperturâ ovatâ; canali brevi, subrecurvo.

An elongate conical shell, with rather convex volutions, transversely ribbed, (the angle forming the first ridge) the posterior edge depressed; the aperture is ovate, and the columella slightly recurved. In the earlier volutions the upper band and occasionally the second one are granulated; but, as the shell increases in size, these granulations become simple continuous bands, and which on the last volution are five in number, the central one being the most prominent. Some specimens in Mr. Edwards's collection from the fresh-water white sand of Headon Hill, are more granulated, and resemble the *C. pseudo-cinctum*, the flattened volutions being the chief characteristic.

Locality.—From the Headon series in Colwell Bay, where it is very abundant. It occurs also at Hordwell, in the estuary formation.

Cerithium concavum. Sow. sp.—Plate 4, fig. 9.

Potamides concavus. Sow. Min. Con. t. 339, f. 1, 2.

Cerithium concavum. Desh. Coq. Fos. t. 46, f. 1, 2.

Var. Cerithium rusticum, Desh. Coq. Fos. t. 46, f. 3, 4.

Localities.—Headon Hill, Colwell Bay, also at Hordwell and in the estuary series at Long Mead End, Hampshire. (Mr. Edwards's collection.)

Cytherea incrassata. Sow. sp.—Plate 4, fig. 10.

Venus incrassata. Sow. Min. Con. Tab. 155, figs. 1, 2.

Locality.—This is an abundant species in the upper marine bed of Colwell Bay, it is also found at Bembridge and Lyndhurst, Hampshire.

Cyrena Wrightii. Forbes.—Plate 4, figs. 11, 11 *a*, *b*.

Cyrena pulchra, var. Plate 3, fig. 1.

An examination of a series of specimens of this form would suggest that it is only a variety of *Cyrena pulchra* (Sow.). The specimen figured is rather more gibbose, the umbones are consequently more incurved, the anterior margin is not so much produced, and the posterior is not so broadly truncate as in *C. pulchra*. These characters, together with some slight differences in the cardinal teeth, are characters scarcely sufficient to separate it as a distinct species, as some of the specimens of *C. pulchra* present corresponding differences among themselves when examined in different stages of growth.

Locality.—From the Headon series.

PLATE 5.

Headon Series.

Pleurotoma plebeia. Sow.—Plate 5, figs. 1, 1 *a*, *b*.

Pleurotoma plebeia. Sow. in Dixon. Geology and fossils of the Cretaceous and Tertiary formations of Sussex.—Plate 6, fig. 23 (*var.* a. gracile, Forbes's MS.).

The specimen exactly corresponds with that described and figured by Mr. Sowerby (loc. cit.) from Bracklesham Bay; and also with some shells from Cuise-lamotte, sent by Mons. Deshayes to Mr. Edwards, who has compared specimens from various localities, and has ascertained that this species ranges from the London clay to the Headon Hill series. Occasional varieties in the ornamentation occur, according to the different localities, the details of which will be given by Mr. Edwards in the Memoirs of the Palæontographical Society, when treating of the eocene Pleurotomæ.

Localities.—Potter's Bar, Highgate, Clarendon Hill, Southampton; Bracklesham, Bramshaw, High Cliff, Barton, Alum Bay (No. 29, Prestwich); Colwell Bay, *Upper Marine* of Headon Hill, and Hordwell, and also at Lyndhurst, Hampshire.

Pleurotoma plebeia, *var.*—Plate 5, fig. 2.

Pleurotoma plebeia (*var.* b. testâ tumidâ, majori, fortiori. Forbes's MS.)

The White Cliff Bay shell is so much thicker, shorter, wider, and larger, that at first sight it appears a distinct species, but the sculpture is identical in all essential points in both shells, the keel is crenated, as if studded with small knobs; the ridges between the sulci are prominent, but not crenate; above the keel the shell is hollowed out, and close to the suture are one or two fine round spiral ribs. (Forbes's MS.).

	Var. *a*.	Var. *b*.
Length	$\frac{5}{8}$ in.	1 in.
Breadth of body whorl	$\frac{3}{8}$ „	$\frac{4}{10}$ „
Length of spire	$\frac{4}{13}$ „	$\frac{11}{36}$ „
Length of aperture	$\frac{3}{10}$ „	$\frac{11}{36}$ „

Locality.—From the middle Headon series.

Pleurotoma innexa. Solander sp.—Plate 5, fig. 5.

Murex innexus. Brander, Foss. Hanton.—Fig. 30.

Localities.—High Cliff, Barton, Hants; Colwell Bay, White Cliff Bay, and at Alum Bay (No. 29, Prestwich), Isle of Wight; and Bracklesham Bay, Sussex.

Borsonia, Bellardi. *Cordieria*, Rouault.

Borsonia. L. Bellardi, 1838. Bull. Géol. Soc. de la France, vol. 10, p. 30.

L. Bellardi, Monografia delle Pleurotome fossili de Piemonte, 1845. Mem. d. Reale Acad. Scien. del Torino, p. 610.

Cordieria.—Rouault, Mem. Soc. Géol. de la France, 2 ser. vol. 3, p. 487.

Testâ fusiformi, canali producto, subrecto, plus minusve elongato; labio supernè fissurâ vel sinu emarginato; columellâ unâ vel pluribus plicis instructâ.

The genus *Borsonia* was constituted by Bellardi for a group of Pleurotoma, having a single fold on the columella. M. Rouault has given the name *Cordieria* for those Pleurotomæ with two folds on the columella, to which section the following species belongs, and which group can scarcely be regarded as generically distinct.

Borsonia sulcata. Edwards.—Plate 5, figs. 3, 3 *a*, *b*.

Borsonia sulcata. Edwards's MSS.

B. testâ ovato-fusiformi, semi-costatâ, transversim sulcatâ; anfractibus 6–8, convexiusculis, ad suturam marginatis, supernè excavatis; costis crassis, rotundatis; aperturâ ovatâ, in canali per-brevi, lato, exeunti, labio arcuato; columellâ obliquâ, biplicatâ.

A small ovately fusiform shell, with an elevated pointed spire, formed of from six to eight somewhat tumid volutions, longitudinally ribbed and transversely

sulcated; a deep furrow runs round the upper margin of the whorls, and is separated from the suture by a somewhat thread-like elevation. The longitudinal ribs are very short and broad, extending to the middle of the whorl; the transverse furrows are wide and distinct. The aperture is ovate contracted in front, where it ends in a short, moderately wide canal; the outer lip is sharp, arched, and presents a deep curvature in front of the suture; the columella is rather oblique, and bears about the middle two very oblique folds.

Length - - - - - $\frac{3}{8}$ in.
Breadth of the body whorl - - - - $\frac{2}{10}$ "

Localities.—Colwell Bay, Isle of Wight; also in Mr. Edwards's collection; Hordwell, Hampshire, where it has been found by Mr. Higgins.

Pleurotoma Headonensis. Edwards.—Plate 5, fig. 4.

Pleurotoma Headonensis. Edwards's MS.

P. testâ gracili, fusiformi; anfractibus sex convexiusculis, semi costatis, spiraliter sulcatis, supernè sulco profundo exaratis ad suturam marginatis; costis obliquis numerosis; aperturâ sublanceolatâ, arcuatâ; caudâ brevi.

A slender fusiform shell, with six slightly convex whorls, transversely sulcated and longitudinally ribbed, a sharp elevated line runs round the sutural margin, the space between which and the shoulder is deeply excavated; the longitudinal ribs are oblique, numerous, rounded, and extend scarcely to the middle of the whorl. The aperture is lanceolate, and terminates in a short, moderately wide canal, somewhat oblique, owing to the curved form of the columella. The sinus which is in the furrow immediately above the shoulder, is wide but not very deep.

Length - - - - - $\frac{3}{10}$ in.
Width - - - - - $\frac{1}{8}$ "
Length of the spire - - - - $\frac{2}{13}$ "
Length of the aperture - - - - $\frac{1}{8}$ "

Localities.—Headon Hill, Colwell Bay, and White Cliff Bay, in the Upper Marine of Hordwell, Hants.

PLATE 6.

Headon Series.

Ancillaria subulata. Sow.—Plate 6, figs. 1, 1 *a*.

Ancilla subulata. Sow. Min. Conch. Pl. 323, figs. 3, 4.
? *Ancilla buccinoides.* Lam. Ann. du Mus. 1, p. 475.
? *Ancillaria buccinoides.* Desh. Coq. Foss. Pl. 97, figs. 11–14.

Localities.—This is an abundant species, and subject to some variation in form according to the localities. M. Deshayes notices the same fact with regard to the specimens from the Paris basin, and considers the shell described by Sowerby as *A. subulata* and that by Lamarck as *A. buccinoides* to be the same species.

Localities.—Bracklesham Bay, Sussex; Bramshaw, Barton, Brockenhurst, Lyndhurst, Long Mead End; Hordwell, Colwell Bay.

Melanopsis subfusiformis. Morris.—Plate 6, figs. 2, 3.

M. testâ ovatâ, conicâ, lævi; spirâ plus minusve elevatâ, anfractibus 6 & 8, subplanulatis; margine suturali cavata, expansâ: aperturâ subovali, spiram in longitudine æquanti, columellâ arcuatâ.

An ovate conical shell having the spire more or less elevated, with six to eigth rather flattened volutions, the sutural margin extending far over the preceding whorl, the space between the suture and the shoulder is hollowed out. The aperture is rather oval, and nearly equal to the length of the spire; the columella is arched.

On comparing a series of the young individuals of this shell, with *M. fusiformis*, Sow., the forms pass so gradually from one to the other, that it is difficult to separate them.

Locality.—From the Headon series.

Melanopsis subulata. Sow.—Plate 6, fig. 4.

Melanopsis subulata. Sow. Min. Con. Pl. 332, fig. 8.
Melanopsis fusiformis. Sow. Min. Con. Pl. 332, fig. 6.

Locality.—From Headon Hill.

Mr. Edwards has this species from the lower beds of Hempstead Cliff.

Melanopsis subcarinata. Morris.—Plate 6, figs. 5, 6.

M. testâ fusiformi, lævi, spirâ elevatâ, carinatâ, anfractibus 6–8, ventricosis, anfractu ultimo spiram in longitudine superanti: aperturâ ovatâ, anticè effusâ; columellâ valdè arcuatâ.

A smooth fusiform shell, of six to eight volutions, with an elevated and pointed spire, the last volution rather longer than the spire. Aperture ovate, with the columella strongly arched.

Locality.—Headon Hill, where it is very abundant in a calcareous matrix.

Melanopsis fusiformis. Sow.—Plate 6, fig. 7.

Melanopsis fusiformis. Sow. Min. Con. Pl. 332, fig. 1.

On comparing this shell with a series of the young individuals of *M. subfusiformis*, figs. 2, 3, it is difficult to regard it as a distinct species, although the short, somewhat obtuse spire, would apparently justify the separation.

Locality.—Hordwell, Hampshire; and Colwell Bay, Isle of Wight.

Melanopsis carinata. Sow.—Plate 6, figs. 8, 9.

Melanopsis carinata. Sow. Min. Con. Pl. 523, fig. 1.

These two shells are considered to be varieties of the shell figured by Mr. Sowerby as *Melanopsis carinata* (loc. cit.).

Locality.—It occurs abundantly in the estuary formation of Headon Hill, in which the *Melania muricata* and the so-called *Bulimus politus* occur; it is also found at Hordwell and in the Bembridge and Hempstead series.

Mr. Sowerby states (Min. Con. vol. 6, p. 41) that this species was found abundantly in a light greenish clay in a well near Newport, Isle of Wight, in 1818, accompanied by *Potamides ventricosus* (Min. Con. t. 341, fig. 1), a new subulate Melania, and various other freshwater shells. It also occurs in a similar clay, and accompanied by the same shells, from Hempstead Cliff to Cowes, and among the freshwater series on the opposite cliffs of Hampshire, as we learn by specimens collected by the Rev. Prof. Sedgwick and Sir C. Lyell.

Melanopsis brevis. Sow.—Plate 6, fig. 10.

Melanopsis brevis. Sow. Min. Con. Pl. 523, f. 2.

Locality.—From Colwell Bay. Mr. Edwards has a series of fine and large specimens of this species from Hordwell, whence the shell figured by Mr. Sowerby was obtained by Prof. Sedgwick.

Cyrena deperdita. Lam.—Plate 6, figs. 11, 11 *a*, *b*.

Cyrena deperdita. Desh. Coq. Foss. Pl. 19, figs. 14, 15.

Cyclas deperdita. Lam. Ann. du Mus. Tom. 7, p. 425.

Localities.—From the Headon series, and also in the estuary deposit at Long Mead End, Hants.

Nucula Headonensis. Morris.—Plate 6, figs. 12, 12 *a*, *b*.

N. testâ ovato-transversâ, depressâ, lævi, latere antico brevi, subproducto, margine arcuato, posticè angusto, margine ventrali subarcuato, intùs crenulato: lunulâ prominulâ, sulco perspicuo circumdatâ.

An ovately transverse and somewhat depressed shell, with the anterior margin short and slightly produced, the posterior extremity narrowed, the ventral margin arched and internally very finely crenulated; the lunule prominent, and surrounded by a conspicuous furrow.

Locality.—From the middle Headon series in Colwell Bay.

Cyrena gibbosula. Morris.—Plate 6, figs. 13, 13 *a*, *b*.

C. testâ parvulâ, subtrigonâ, gibbosâ, anticè productâ, attenuatâ, posticè obtusè angulatâ, margine rotundato.

A small somewhat gibbose shell, produced and narrowed at the anterior extremity; the posterior portion obtusely angulated, and the extremity much rounded. The cardinal teeth are more divergent than is usually the case in this genus. The form of one of the specimens figured, appears to be modified by some accident. This shell presents considerable resemblance to the young state of the *Cyrena obovata*, Sow., with which the examination of a larger series may probably lead us to identify it.

Locality.—From the Headon series.

JOHN MORRIS.

Notes on the Entomostraca, by T. R. Jones, Esq., F.G.S., Assistant Secretary of the Geological Society.

Entomostraca of the Osborne and Hempstead Series.

In noticing the four following species of Entomostraca from the fluvio-marine deposits of the Isle of Wight, I shall not attempt to describe the generic and sub-generic characters; these will be better understood by reference to my monograph of the Tertiary Entomostraca of England, now in preparation for the Palæontographical Society, than by a curtailed notice of this somewhat intricate subject in these pages.

Judging from the conditions under which allied species are at present found, and from the mode of occurrence in which others occur in the pleistocene beds of Grays,* Clacton, &c. it is probable that the three new species here described were inhabitants of fresh or slightly brackish waters, and that *Cytheridea Mulleri* lived in brackish or salt water.

1. Candona† Forbesii, spec. nov. Pl. 7, fig. 22 *a*, *b*.

(Monog.‡ Tert. Entom. England, pl. 4, fig. 8, 9, 11.)

Length one sixteenth of an inch.

Valves thin, oblong, rounded at the extremities, narrowest and most depressed anteriorly, most convex at the posterior third; posterior border margined with a slightly raised rim; dorsal border arched; ventral slightly incurved. Surface smooth, fine punctuations visible in the transparent valves under the microscope with transmitted light.

This species resembles the recent *Candona reptans* and *C. Richardsoni* of the Woolwich beds; but certain modifications of shape and proportional size separate all these forms.

Loc.—*C. Forbesii*§ occurs in great numbers and in different stages of growth, chiefly as single valves, compressed between the laminæ of shales throughout the Hempstead series, Hempstead Cliff, and in a better state of preservation in some of the pyritous bands. It is met with in a compressed state in the green shales of the Osborne series of Cliff End, Colwell Bay. It is found also at Hordwell (Mr. F. Edwards's collection).

I have dedicated this abundant and characteristic species to Edward Forbes, whose name is so intimately associated with the Hempstead deposits and their fossils.

2. Cytherideis‖ unisulcata, spec. nov. Pl. 7, fig. 23.

(Monog. Tert. Entom. England, pl. 4, fig. 10.)

Length one fortieth of an inch.

Valves triangular, broadest anteriorly, convex, impressed across the middle by a transverse furrow.

The only specimen I have met with is very small (probably a young individual), and not well preserved. Its characters, however, are sufficiently distinct for notice.

Loc.—It occurs with *Candona Forbesii* in the Osborne series at Cliff End, Colwell Bay.

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* Annals Nat. Hist. ser. 2, vol. vi. p. 25.

† *Candona* (Baird) is a genus of minute bivalved Entomostracan Crustacea. It is closely allied to the common *Cypris* (Müller), and usually inhabits fresh water.

‡ The references to the monograph, now in preparation, are inserted for the purpose of rendering the subject more complete.

§ This is probably the species which was referred to by Mr. Prestwich, Brit. Assoc., 1846; and by Sir C. Lyell, Geol. Trans. ser. 2. vol. iii. p. 288.

‖ *Cytherideis* is a subgenus (Jones, M.S.) of *Cythere* (Müller)

3. CYTHERIDEIS UNICORNIS, spec. nov. Pl. 7, fig. 24–26.

Length one twenty-fourth of an inch.

Valves thick, triangular in the young state, almost oblong when adult, broadest and most depressed anteriorly. Young individuals are impressed in the middle of the dorsal portion of the valve with two more or less distinct transverse furrows, the posterior of which is the largest and most constant; the anterior furrow is shorter and more oblique than the other, and often runs into it, forming the small arm of a Y-like impression: the furrows are associated with several irregular tubercles, of slight elevation, one of which, placed behind the chief furrow, is persistent and increases in size, whilst the others disappear as the animal grows older and the carapace enlarges; the furrows also gradually disappear with the advanced growth of the animal, until a single slightly recurved spine or pointed tubercle remains on the postero-dorsal third of each valve. Surface of the valves faintly and irregularly punctate.

Loc.—*C. unicornis* is very plentiful in a crushed state between the laminæ of a dark grey marl (D. 6) of the Lower [?] Hempstead series, Hempstead Cliff.

4. CYTHERIDEA* MULLERI, Münster sp. Pl. 7, fig. 27–28.

C. Mulleri, represented by several varieties, is common throughout the tertiary deposits of Europe, and is found also in the present seas. In England it occurs fossil in the Woolwich series, in the Barton Clay, and in a tertiary oyster-band at Colwell Bay.

Loc.—This species abounds in the marls and shales of Hempstead Cliff throughout the series. Several gradations between the smooth and the torose or embossed forms are to be met with, sometimes even on one hand-specimen of the shales; the most torose variety (var. *torosa*, Q. J. G. S. *loc. cit.* fig. 8) occurs in the buff marl with selenite, eight or nine feet above the Rissoa-bed with Planorbis.

C. Mulleri also occurs, but rarely, in the green shales of the Osborne series at Cliff End, with *Candona Forbesii*.

Table of the Occurrence of the above-described Species.†

Upper Hempstead	Candona Forbesii. Cytheridea Mulleri.
White Band	Candona Forbesii. Cytheridea Mulleri.
Lower Hempstead	Candona Forbesii. Cytheridea Mulleri. Cytherideis unicornis.
Osborne Series (Cliff End, Colwell Bay)	Candona Forbesii. Cytherideis unisulcata (rare). Cytheridea Mulleri (rare).

July, 1856. T. RUPERT JONES.

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* *Cytheridea* (Bosquet. genus) is a subgenus of *Cythere* (Müller). For detailed notices and figures of *C. Mulleri* see Bosquet, Entom. foss. terr. tert. France et Belgique, [Mém. Couronn. R. Acad. Belgique, vol. xxiv.,] p. 39, pl. 2, fig. 4, *a–f*; Jones, Quart. Journ. Geol. Soc., vol. x. p. 160, pl. 3, figs. 7, 8; Monog. Tert. Entom. England, pl. 5, figs. 4, 5; pl. 6, figs. 10–12.)

† Generally one or other of the species predominates in the several beds of "Cyprisshale." In the "Corbula beds" *C. Mulleri* is the most numerous; in the shales of the "White Band," sometimes *C. Forbesii* and sometimes *C. Mulleri* predominates; and *C. Mulleri* often occurs by itself (for instance, in a bed with *Rissoa Chastelii*, and in another with *Modiola Prestwichii*). In the pyritous bands, associated with the "Seed-beds," *C. Forbesii* is rarely accompanied by *C. Mulleri*. But in another pyritous band, with *Melania muricata*, above the "Black Band," *C. Mulleri* is the only form.

Note on the Gyrogonites (Chara), by J. W. Salter, Palæontologist to the Geological Survey.

The accompanying Plate of the *Gyrogonites*, or seeds of Chara, is given chiefly to illustrate Prof. Forbes's view of the distribution of these bodies in the fluviatile series of the Isle of Wight. A few remarks on them are, however, necessary.

That distribution, as stated by himself in the Quarterly Geological Journal, vol. ix. p. 265, &c., as also supra, p. , , , and sections, is as follows :—

Hempstead Series	1. Chara medicaginula. Brongn. Pl. 7, f. 1–2. 2. Chara helicteres. Brongn. Pl. 7, f. 3–5.
Bembridge Series	3. Chara tuberculata. Lyell. Pl. 7, f. 11-14.
Osborne (St. Helen's) Series	4. Chara Lyellii. Forbes MSS. Pl. 7, f. 7–10. (C. medicaginula. Lyell.)
Headon Series	5. Chara Wrightii. Forbes MSS. Pl. 7, 15–21.

(This name appears not to have been given by Forbes in the memoir above referred to, but it is known that he intended to apply it to the species.)

With regard to the distinctness, or otherwise, of the species above enumerated, it would be premature to speak positively; but having examined a considerable number of them from the different localities and beds quoted by Professor Forbes, I am unable to see the grounds on which he decided to separate the *C. Wrightii* of the Headons from *C. Lyellii* of the Osborne series, or either of these from the old figured species from the Paris basin (*Chara medicaginula*). Nor is the distribution of the species in the different beds quite so limited as it appeared to be when examined by the Professor, inasmuch as *C. tuberculata*, both rough and smoother varieties of it, ranges into the Hempstead series itself; while the species called *C. Lyellii* by Forbes (fig. 7–10), distinguished by the few whorls, is certainly found in the Bembridge and also in the Headon beds, where it is associated with an elongate variety (or species) which agrees very well with the figured *C. helicteres* of Brongniart.

Hempstead Species.

1, C. helicteres. Brongn. Pl. 7, fig. 3–5.
2, C. medicaginula. Brongn. fig. 1–2.

As we are unable to find among the specimens collected from Hempstead any which would answer perfectly to the Brongniartian figures, to which Forbes made special reference, we have reproduced those figures in the plate.

C. helicteres is, according to the French author, the largest of the three species he describes. To these we add,

C. tuberculata. Lyell, var. Pl. 7, fig. 6, 13, 14.

That these belong to the species so common in the Whitecliff section, is scarcely at all doubtful; they differ from its ordinary forms in having fewer whorls, 8 or 9 instead of 10 or 11 :—this number, however, is often not exceeded in specimens from the Bembridge limestone.

When fully developed, the nucules generally shew the tubercles set on a convex surface, and connected by an obscure ridge. This ridge, however, is often wanting, and the surface of the whorls flat or slightly concave, owing doubtless to the shrinking of the spiral tubes from pressure. Our figure 13, from the Hempstead beds, shews this in an extravagant degree. (Found by Prof. J. Morris.)

Var. Morrisii, fig. 14. Oblong, tubercles obscure, corona prominent.

The specimen represented is a good deal worn, and has the tubercles more obscure than they usually are in this locality. The whorls are very prominent, because the seed-vessel was ripe when embedded, and the ridge connecting the tubercles is in some parts quite distinct. Among Forbes's rough sketches is one of this variety.

Loc.—Hempstead Cliff. (Found by Prof. J. Morris).

Bembridge Series.

C. tuberculata. Pl. 7, fig. 11, 12.

Ref. Lyell, in Geol. Trans., 1st series, vol. ii. pl. 13.

Sir C. Lyell's figure shews the tubercles extending quite down to the base,—in our specimens a short space is clear of them.

Loc.—St. Helen's; Whitecliff Bay; Bembridge; all in the Bembridge limestone.

C. Lyellii. Forbes MSS. Pl. 7, fig. 7–10.

C. medicaginula. Lyell, l. c.

This species, which appears to us not to differ from Brongniart's *C. medicaginula*, has but few 5–7 whorls in general, and is of a globular form, rather depressed at the poles. We have specimens from St. Helen's shewing the whorls convex, and with or without, (fig. 10), a narrow concave border, and from Whitecliff many internal cysts (or nuts as they have been called) with the sharp spiral ridges; also one or two with the intermediate line or ridge like that in Lyell's fig. 3.

Loc.—In Bembridge limestone, upper part, Whitecliff Bay; St. Helen's, in ditto.

Osborne (St. Helen's) Series.

The characteristic *gyrogonite* of these beds, according to Prof. Forbes, is, the *C. Lyellii*, and we have specimens both of the exterior and the interior.

In his rough notes he has sketched this species from the St. Helen's beds, and marked it as *C. medicaginula, vera.*

Loc.—St. Helens, in the sandstone; Osborne Point, in Limnean limestone *under* the grits; also, between Nettlestone Point and the boat-house.

Headon Series.

C. Wrightii. Forbes MSS. Pl. 7, fig. 15–21.

C. medicaginula of Wright, in Ann. N. Hist. 1851, vol. vii. p. 22; and probably of Brongniart.

Globular, or somewhat elliptical, smooth, of 6 or 7 whorls, which are convex when ripe (flattened or concave with a median line or ridge when unripe); corona of low rounded tubercles sunk in a depression on the crown of the nucule, and separated by a furrow from the spiral tubes.

The common species in the Headon series, especially in the bottom layers (*'neritina bed'*) of the upper marine. It is equally plentiful at Hordwell, from whence our figs. 18, 21 are taken, as they illustrate some points more perfectly.

The forms figured (15, 21) although not unfrequent, are less common than such as figures 18 to 20; yet we think no one, who has looked at a series from the same locality, can doubt that all these belong to one species, distinguished by its globular form, few whorls, and depressed apex, from the *C. helicteres*, but agreeing in these respects with the *C. medicaginula*, Brong. Nor, except the more obvious corona, is there any character to separate it from *C. Lyellii*.

Unfortunately, in most cases, the more sure specific characters are absent from these fossil nucules, viz. the coronal joints, which, from their size, or direction, would afford great assistance in distinguishing the several species. Their being so frequently absent in all but the *C. tuberculata* makes it probable the others should be referred to the genus *Nitella*, in which these processes are deciduous. The small depressed crown in *C. Wrightii*, fig. 21, may be only the convex tips of the spiral tubes from which the processes have fallen off. The base of this and all the species, (figs. 1, 3, 6, and 16) shews an even surface, and frequently a small foramen.

The whorls vary in number in *C. Wrightii* from 5 to 7, but are usually 6, and in fully ripe specimens (15, 21) have the spires quite convex, and distinctly separated from each other. Others have them rather less convex, and a third form has a small intermediate ridge like that in Brongniart's figure. When the thread is more contracted, as in fig. 20, the central convexity is narrower, and the marginal ridge appears on each side of it, as more distinctly seen in fig. 18.

Fig. 19 shews, perhaps, the extreme form, when the contraction is greatest and the convexity of the thread reduced to merely a central line. But figs. 16, 17, probably represent the inner cysts of ripe nucules, when the outer spires have fallen

quite off—since they present no trace of a ridge between the sharp projecting edges. The threads, therefore, or at least their outer surfaces, must have been broken away.

Some of the variations above described may be seen in the *Chara vulgaris*, when the nucules have been drying on the field of the microscope. In this condition the turns of the spire may be seen as flat or concave, and either with irregular or quite regular sharp ridges between them, on various specimens, or even on the same nucule. As desiccation of the tubes therefore causes this contraction and variety of form, it is more than probable that pressure on partially ripe nucules may have done the same, and hence that all the globular forms of smooth Charæ in these beds, which differ in no other particular except this variation in the form of the whorls, may be referable to a single species—C. medicaginula.

C. tuberculata. var.? or C. helicteres, Brongn.?

There is, however, with these at Headon, a Chara nucule of a longer shape, with more (8 or 9) whorls, and a somewhat pointed apex, which comes nearer to the shape of *C. helicteres* than any we have seen. It occurs, as does the last, with slightly convex, margined, flat, or concave threads, the latter sometimes with a very slightly tubercular ridge in the middle; but some of the ripest and most convex specimens shew such unequivocal tubercles, as to render it probable it is only an extreme variety of the *C. tuberculata*. Can *C. helicteres* of Brongniart be the same species in a somewhat immature state?

Loc.—Headon series; Colwell Bay.

The distribution of the Charæ in the Isle of Wight, so far as the specimens at our command shew, is as follows:—

In the Headon beds *C. medicaginula* (C. Wrightii) is the common fossil, *C. tuberculata* (*C. helicteres*, Brongniart?); being rare.

The Osborne beds are only known to contain one species, the *C. medicaginula* of Lyell, and probably of Brongniart. (C. Lyellii, Forbes.)

In the Bembridge series *C. medicaginula* is rare, and *C. tuberculata*, Lyell, abundant.

And in the Hempstead series the *C. tuberculata* (and a variety of it very like the *C. helicteres* quoted above) are rare fossils.

In these views I am happy to have the concurrence of so able an observer as Prof. J. Morris, who has kindly gone over all the evidence with me.

J. W. SALTER.

July, 1856.

EXPLANATION OF FIGURES.

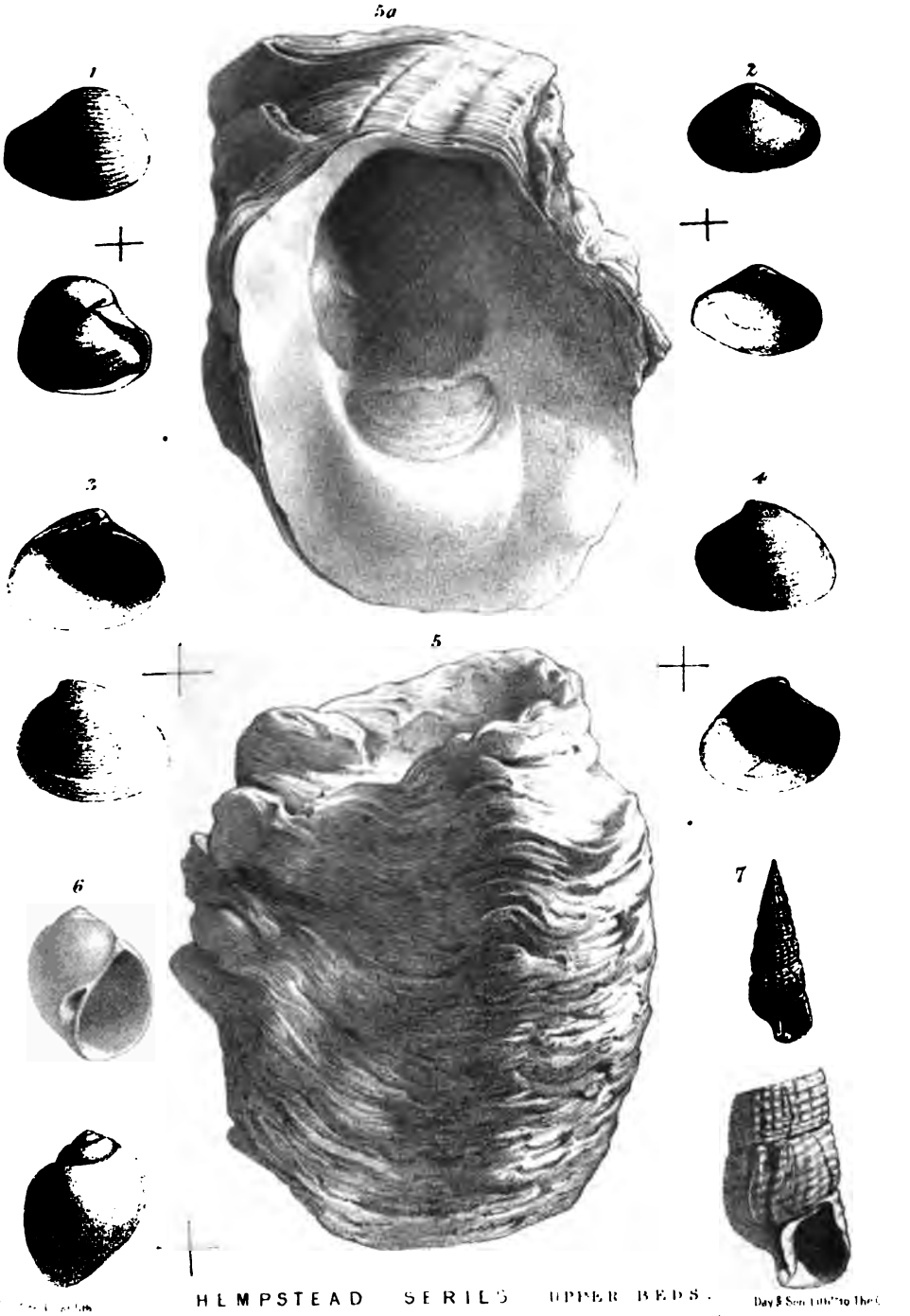
(*The Figures of Charæ are magnified about ten times.*)

Plate 7. fig. 1, 2. CHARA MEDICAGINULA, *Brongn.* (from Brongniart's figure).
fig. 3–5. CH. HELICTERES, *Brongn.*, from the same.
fig. 6. (Internal cyst of Fig. 14, view of the base, wrongly *C. Lyellii* on the plate.)
fig. 7–10. C. LYELLII, *Forbes* (from Lyell's figures of *C. medicaginula*. Geol. Trans.) The internal cyst;—the outer surface of the tubes being broken off.
fig. 8. Unripe specimen with whorls much collapsed.
fig. 9. Nucule, partly ripe, with ouly a slight contraction in each whorl.
fig. 10. id., a fully ripe specimen. St. Helen's limestone.
fig. 11, 12. C. TUBERCULATA, *Lyell*, from Whitecliff.
fig. 13. id., var. with fewer whorls, Hempstead.
fig. 14. id., var. *Morrisii* (Salter), Hempstead. (Fig. 6 is the base view of this variety.)
fig. 15. C. WRIGHTII. *Forbes*, MSS., broken ripe specimen. Headon.
fig. 16. id. internal cyst, base view.
fig. 17. id. ditto, side view.
fig. 18,19,20. id. base and side views of unripe and nearly ripe specimens.
fig. 21. id. fully ripe, and with the base of the corona preserved.

(*Figures of Cypridæ magnified about ten diameters.*)

fig. 22*a*. CANDONA FORBESII, *Jones;* left valve.
fig. 22*b*. The same; dorsal aspect of left valve.
fig. 23. CYTHERIDEIS UNISULCATA, *Jones;* right valve.
fig. 24. CYTHERIDEIS UNICORNIS, *Jones;* left valve, young.
fig. 25. The same; right valve, adult.
fig. 26. The same; dorsal aspect of the united valves.
fig. 27. CYTHERIDEA MULLERI, *Münster*, sp.; left valve, young.
fig. 28. The same; left valve, adult.

PLATE. 1.

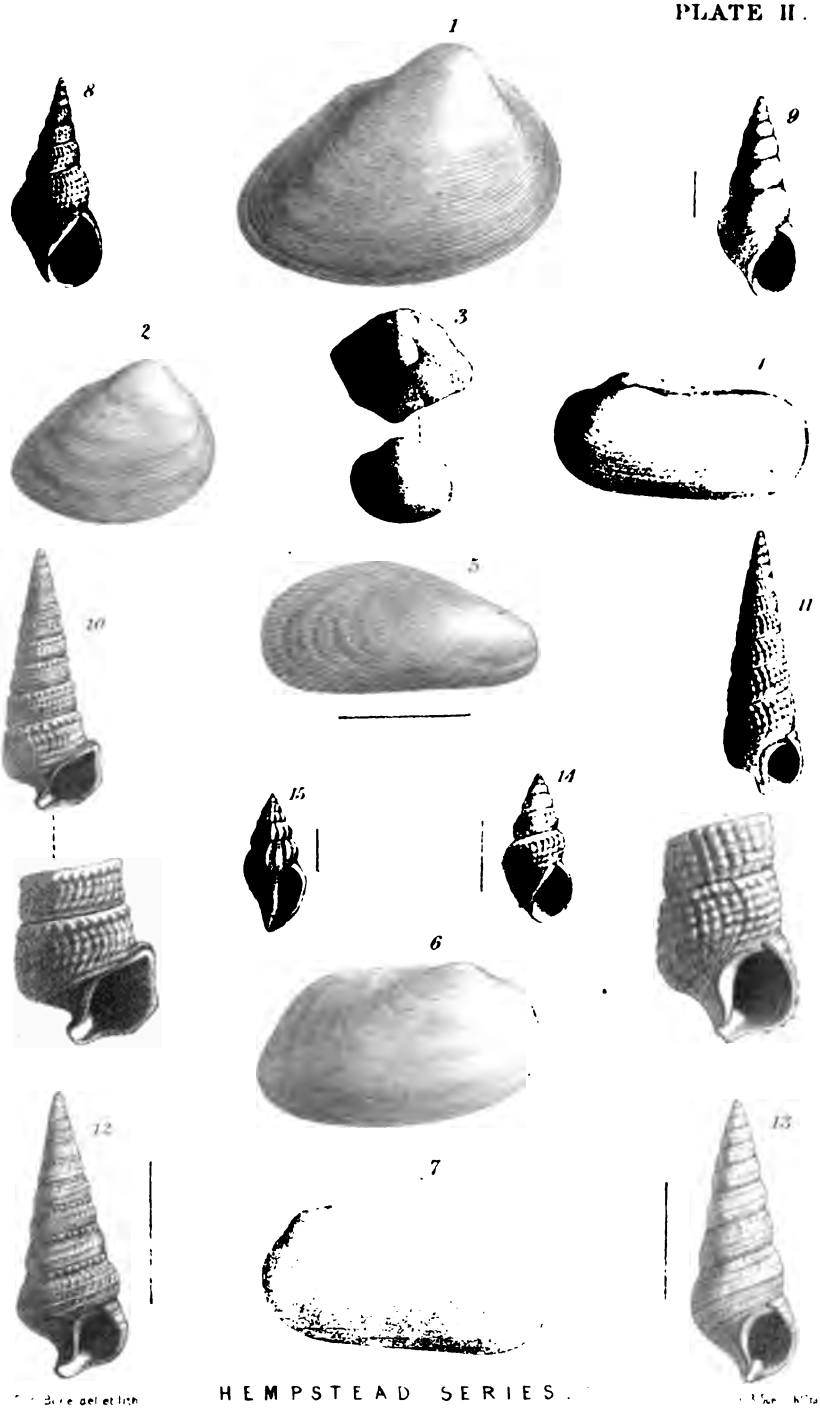


HELMPSTEAD SERIES UPPER BEDS.

Day & Son Lith^rs to the K.

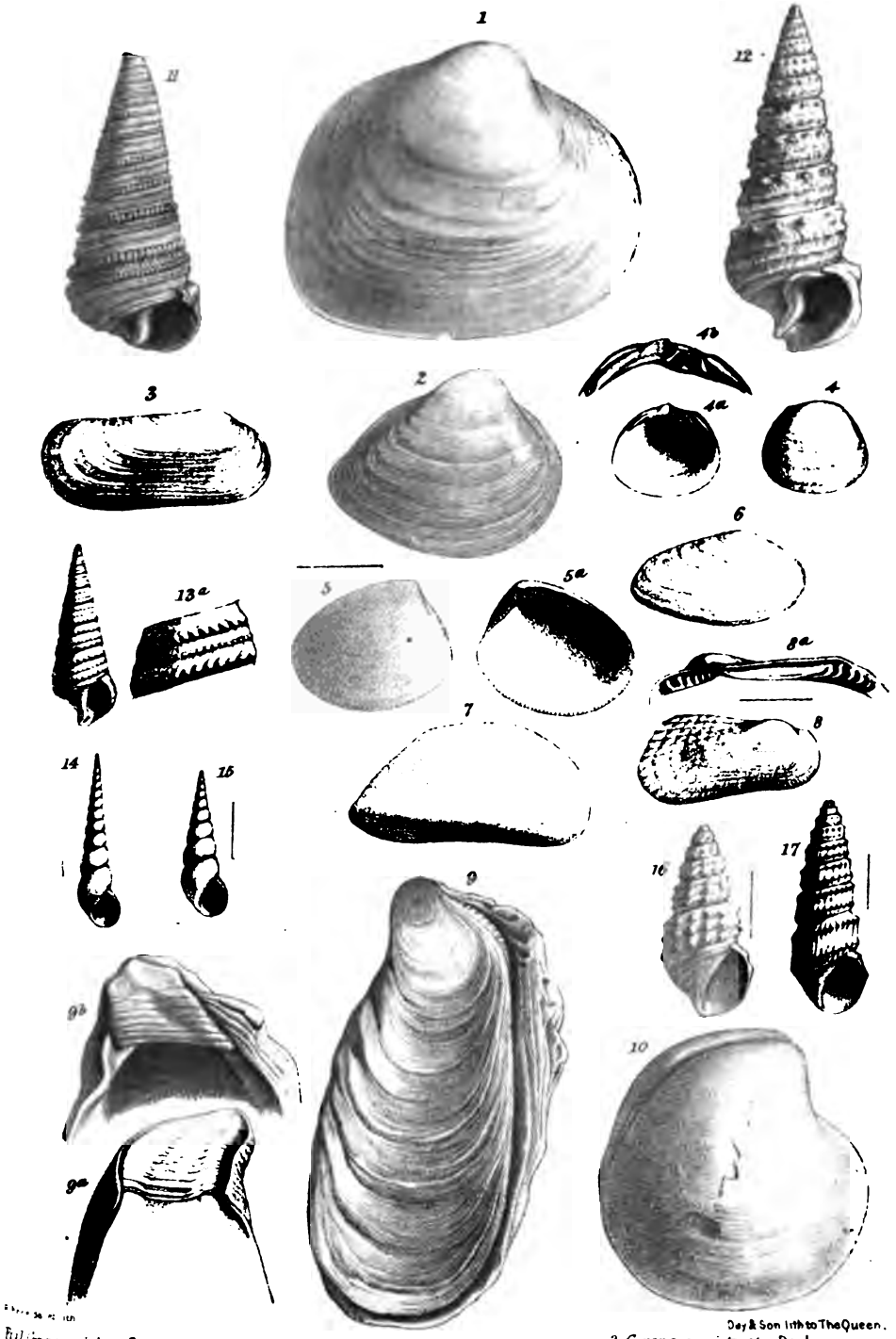
fig. 1 Corbula inæquivalvis Sow. 2 Corbula Nectensis. Forbes. 3 Cyrena semistriata Desh sat
4 Cyrena (Venus) Lyellii Forbes. 5 Cyrena tellinella Lam & Natica labellata Lam
7 Cerithium incrassatum Lam

PLATE II.



HEMPSTEAD SERIES.

Fig 1 2. Cyrena semistriata Desh. *3 Cyclas Bristowi* Forbes. *4 Mya (Panopæa) minor var* Forbes. *5 Modiola Nysiana* Forbes. *6 Unio Gibbsii* Forbes. *7 Unio Austenii* Forbes. *8 Melania inflata* Morris. *9 Melania inflata, var laxa* *10* [illegible] *11 Cerithium plicatum* Lam. *12 Cerithium? aquense* *13 Cerithium serratum* Morris. *14 Melania [illegible]* Morris. *15 Paludina Edwardsii* Mant.

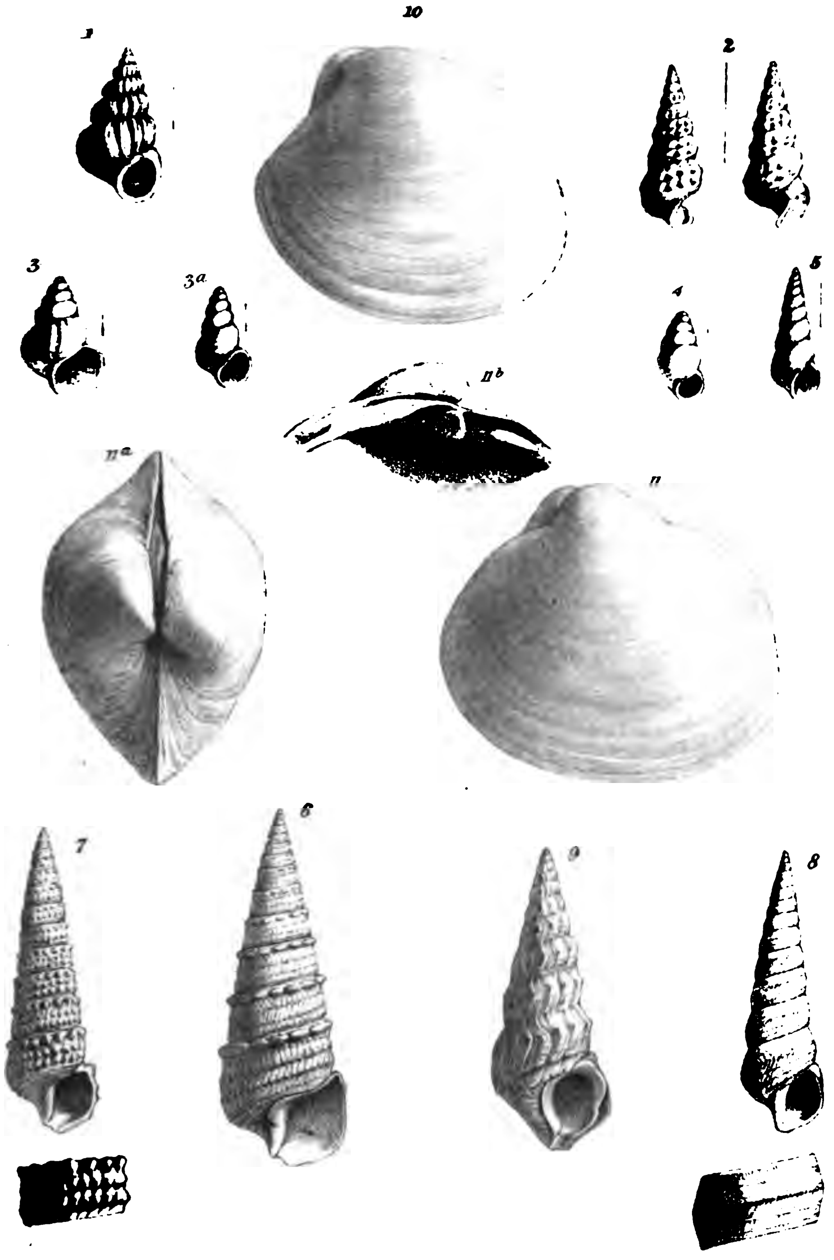


Day & Son lith to The Queen.

BEMBRIDGE MARLS.

Fig. 1 *Cyrena pulchra* Sow. 2 *Cyrena semistriata*, Desh. 3 *Tropeas minor* Forbes. 4 *Cyrena obtusa*, Forbes. 5 *Cyrena ovalis* Sow. 6 *Cyrena transversa* Forbes. 7 *Mytilus affinis*, Sow. 8 *Arca Websteri*, Forbes. 9 *Ostrea vectensis* Forbes. 10 *Cyrena incrassata* Sow. 11 *Cerithium Austeni* Morris. 12 *Cerithium mutabile* Sow. 13 *Cerithium inornatum* Desh. 14 *Cerithium funatum* Morris. 15 *Melania* Morris. 16 *Melania* Morris. 17 *Melania* Morris.

Geological Survey of the United Kingdom. PLATE IV



R. C. Bone del. et lith. Jay & Son Lith. to the Queen

HEADON SERIES.

Fig.1 Scalaria lævis. Morris _ *2 Cerithium ventricosum.* Sow _ *3. Hydrobia Chastilii ?* Nyst *sp.*
4 Nematura parvula. Desh *sp (?)* _ *5 Melania per-acuminata. Charlesworth.* _
6. Cerithium mutabile Desh var.? _ *7 Cerithium pseudo-cinctum.* D'Orb. _ *8 Cerithium trizonatum* Morris
9. Cerithium concavum Sow. _ *10. Cytherea incrassata.* Sow. *sp* _ *11. Cyrena Wrightii*, Forbes.

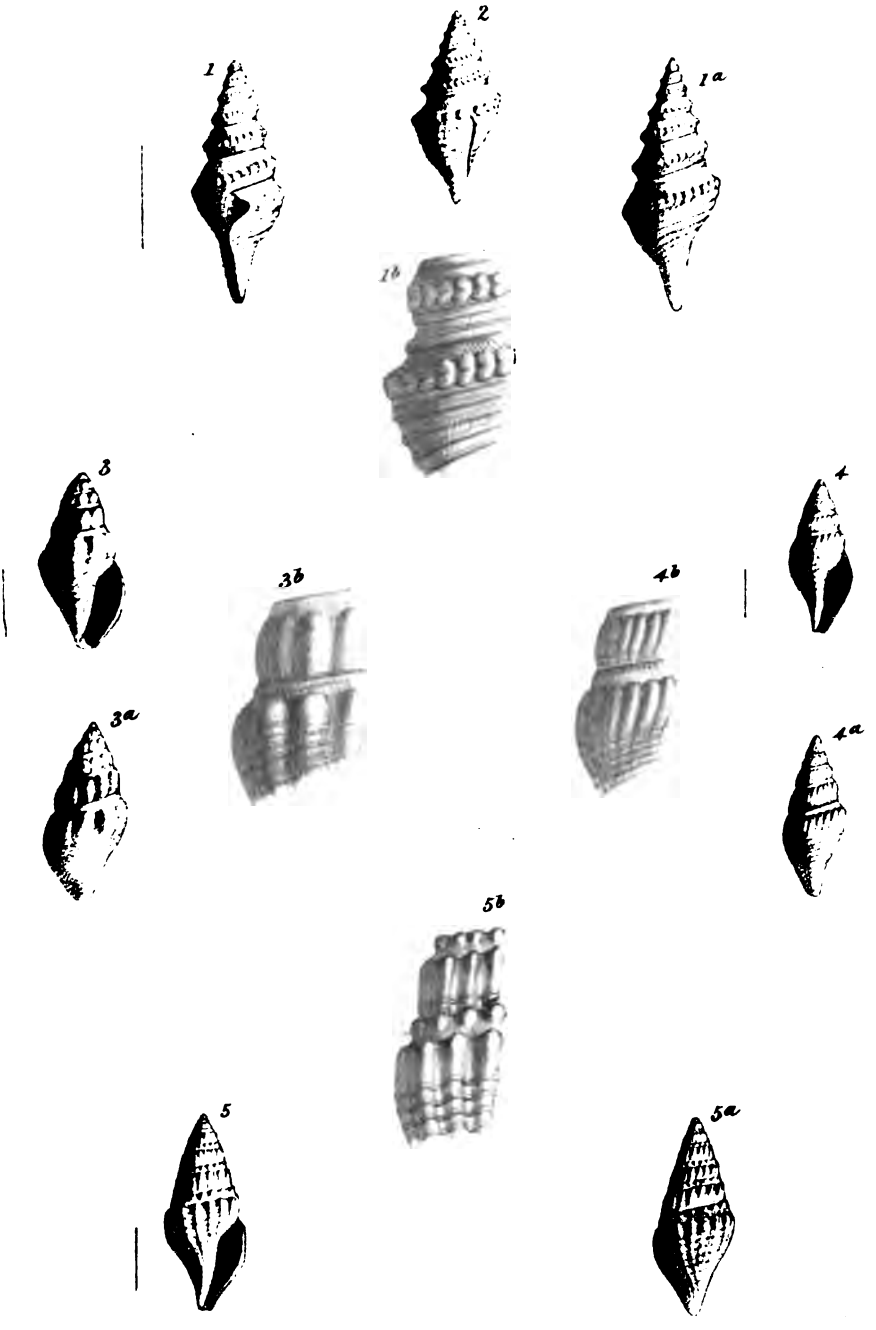
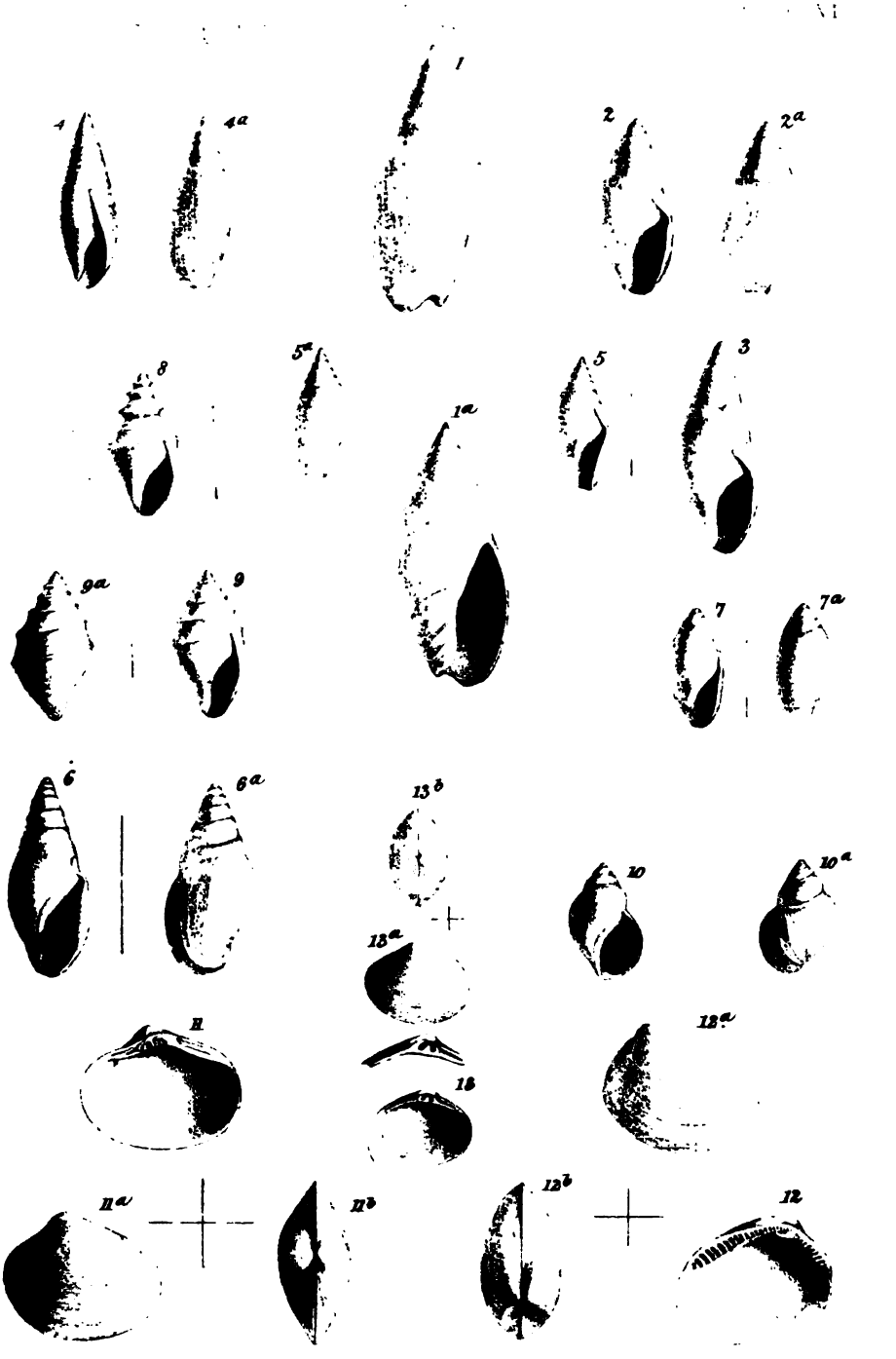


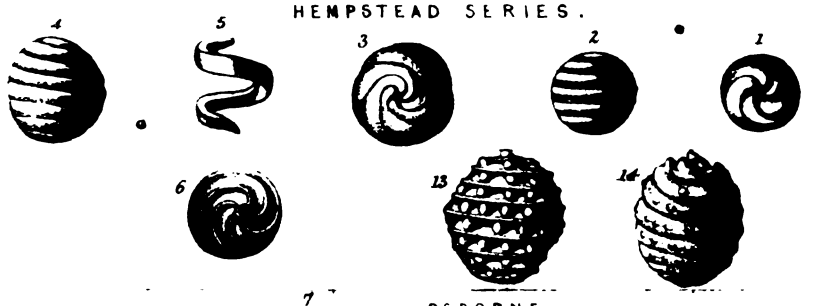
Fig 1 Pleurotoma plebeia Sow. *2 Pleurotoma plebeia, var. 3 Borsonia sulcata* Edwards. *4 Pleurotoma Hordwellensis*, Edwards. *5 Pleurotoma unicava* Solander



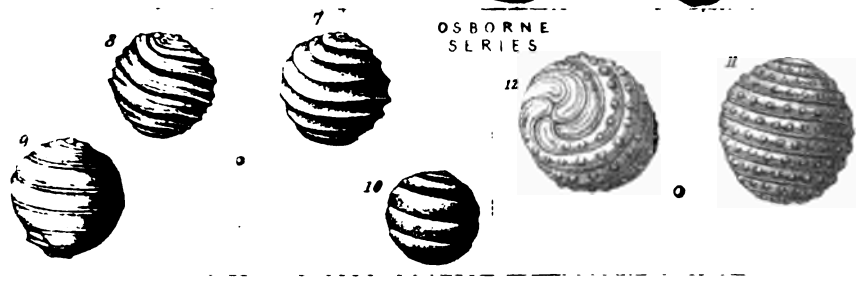
HEADON SERIES.

Fig 1 Ancillaria subulata Sow — *2 3. Melanopsis subfusiformis* Morris — *4 Melanopsis subulata* Sow
5 6 Melanopsis subcarinata Morris — *7 Melanopsis fusiformis* Sow — *8 Melanopsis carinata* Sow
9 Melanopsis brevis Sow — *11 Cyrena deperdita* Lam. — *12 Nucula Headonensis* Morris —
13 Cyrena gibbosula Morris

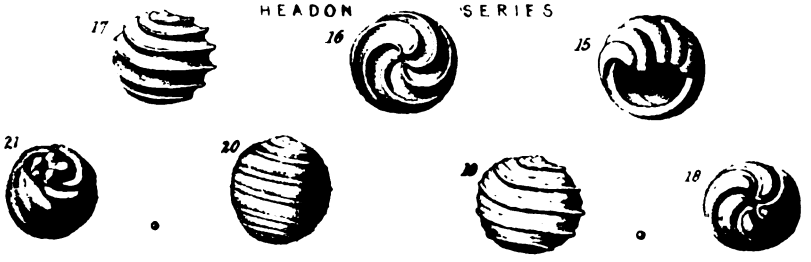
HEMPSTEAD SERIES.



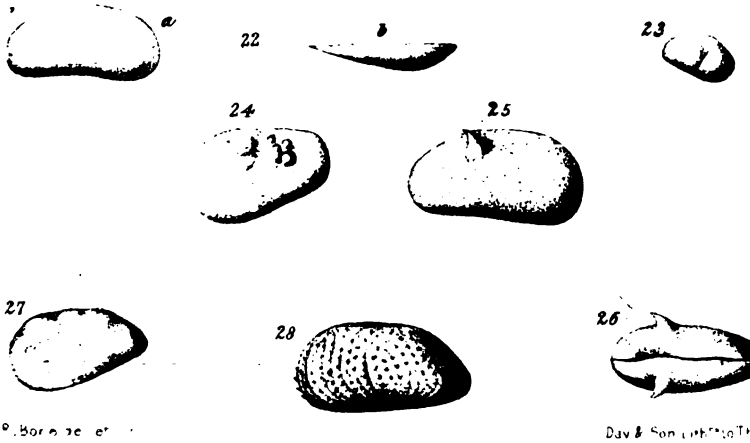
OSBORNE SERIES



HEADON SERIES



HEMPSTEAD & OSBORNE.



J. B. Borrer del.

Day & Son Lith. to The Queen

1 . 2	*Chara*	*mediagnula*	(Brong)
3 5	„	*helicteres*	(Brong)
6 10	„	*Lyellii*	(Forbes)
11 . 14	„	*tuberculata*	(Lyell)
16 21	„	*Wrightii*	(Forbes)

22 Candona Forbesii (Jones)
23 Cytherideis unisulcata (Jones)
24 26 Cytherideis uniformis (Jones)
27 28 Cytherura Mulleri (Jones)

Fig. 22 to 27 magd about 10 diameters

GREAT BRITAIN Plate

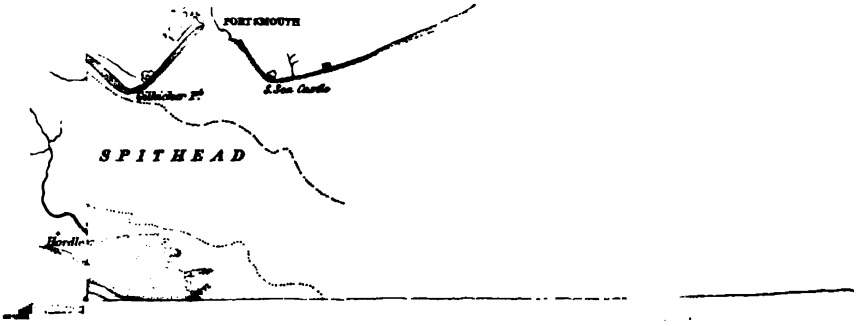


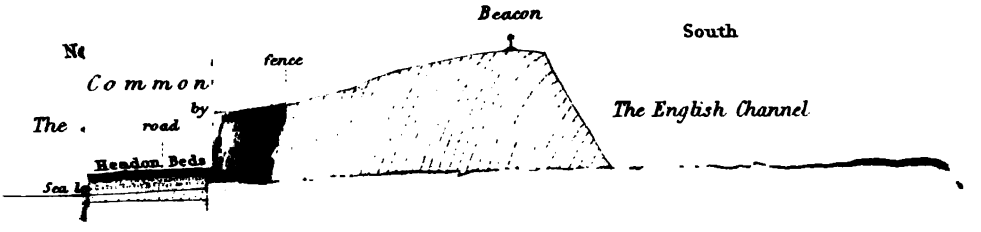
Plate 9.

R V E

near Wo

by Henr

Scale



Y OF G

Plate IV

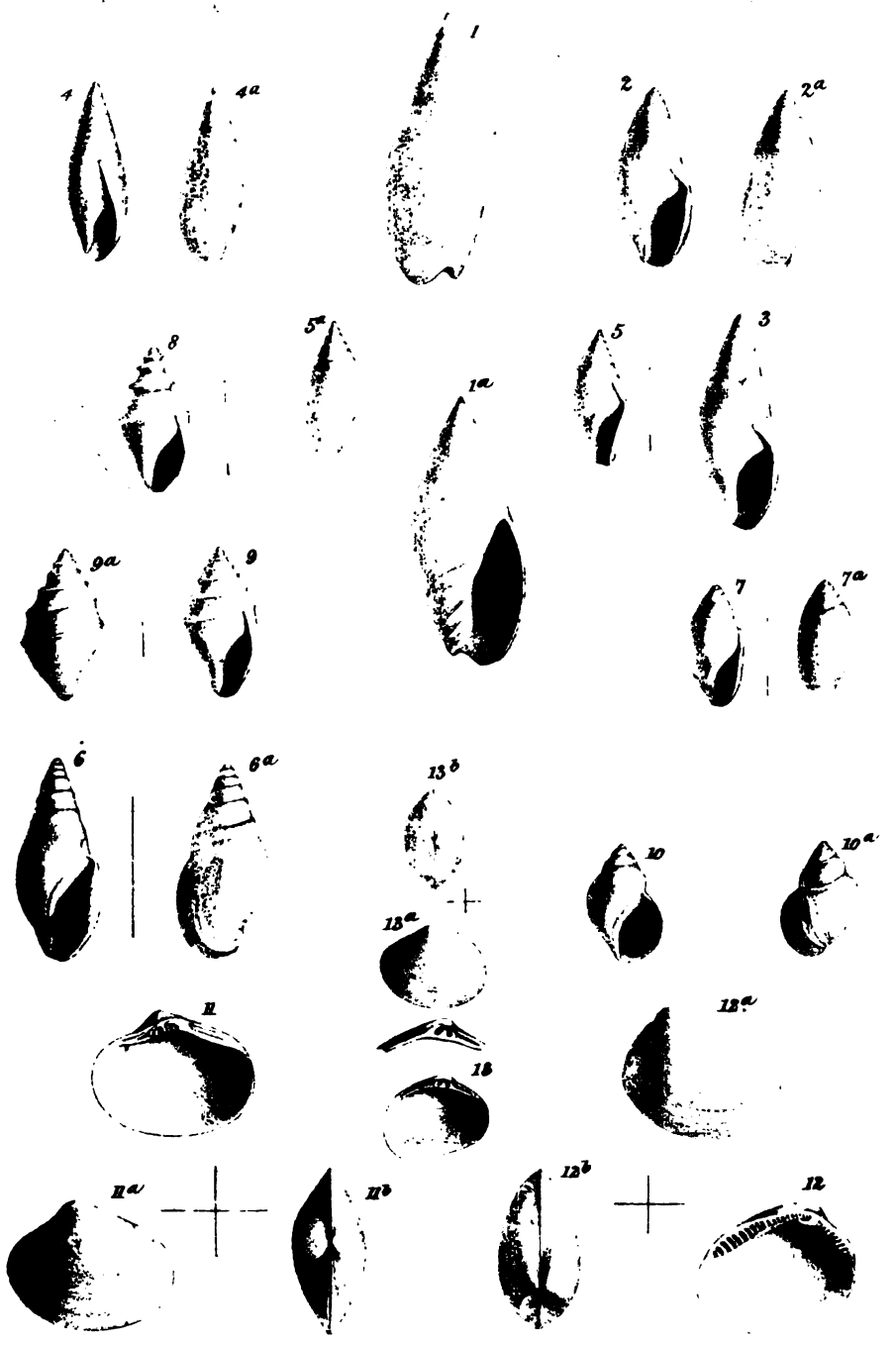
...tical Sectio...

MIDDLE EOCE...

By Edw.d Forbes ...

...The shells much broken in the lower part)
...ventricosum, P. concavus, P. cinctus, Cyrena obovata &c.
...lavata; Ostrea (scattered)
...anguicata
VENUS ...ds about 51° from the top: fossils chiefly
...; Ostrea; Cyrena obovata; Cytherea in-
...delasma.
Dark ...aceous matter (lignite) bands full of
...; Potamides ventricosum;
Blue ...ta, Planorbis lens; P. euomphalus.
Brown ...atter
Sand ...
Red ...
...bivalves
Pure ...broken
...or no fossils
Dark ...
Light ...bands: Cava; Paludina
...alus; Potamomya; Limnaea (crushed)
...lla, Planorbis euomphalus; Paludina (fragments)
Limnaea longiscata, L. caudata
...low
...iformis.
...euomphalus; Paludina, Limnaea longiscata; Bithynia.
...a cycladiformis; Potamides margaritaceus; P. duplex
Yellow ...

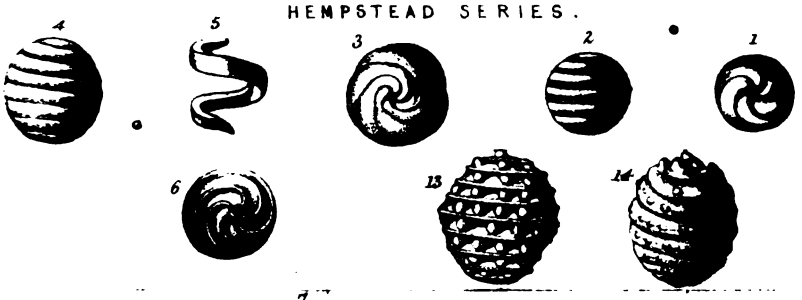
J. W. Lowry Sculpt.



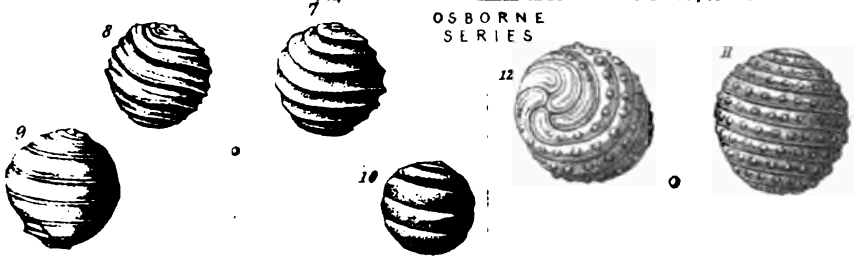
K.F. Pandolfi lith. HEADON SERIES. Day & Son Lith.to the Queen

Fig 1 Ancillaria subulata Sow. _ *2 3. Melanopsis subfusiformis* Morris _ *4 Melanopsis subulata* Sow
5 6 Melanopsis subcarinata Morris _ *7 Melanopsis fusiformis* Sow _ *8 9 Melanopsis carinata* Sow
10 Melanopsis brevis Sow _ *11 Cyrena deperdita* Lam. _ *12 Nucula Headonensis* Morris
13 Cyrena gibbosula Morris

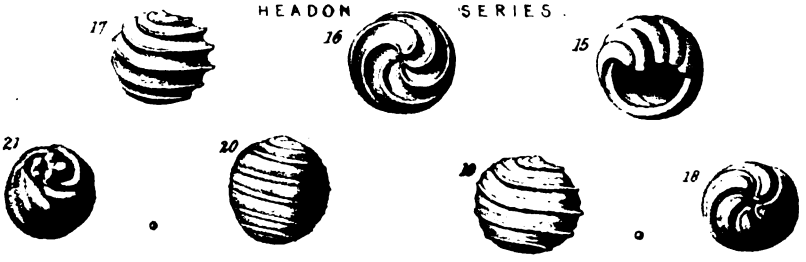
HEMPSTEAD SERIES.



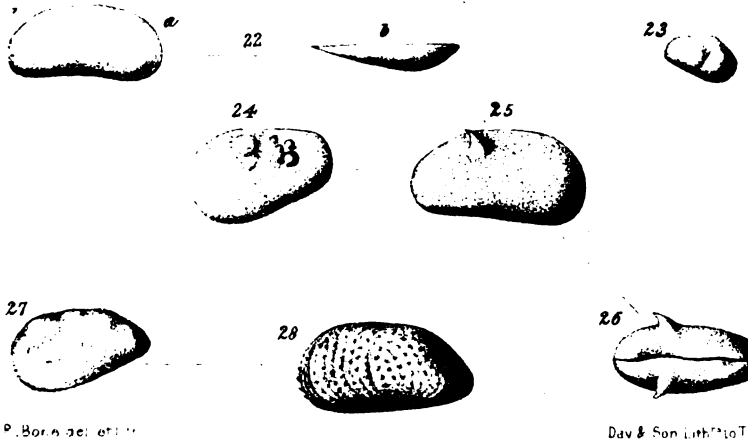
OSBORNE SERIES



HEADON SERIES.



HEMPSTEAD & OSBORNE.



C. P. Boris del. et lith.

Day & Son Lith^rs to The Queen

1 . 2	*Chara*	*medicaginula*	(Brong)
3 5	„	*helicteres*	(Brong
6 10	„	*Lyellii*	(Forbes)
11 . 14	„	*tuberculata*	(Lyell)
16 21	„	*Wrightii*	(Forbes)

22 Candona Forbesii (Jones)
23 Cytheridea unisulcata (Jones)
24 26 Cytheridea unicornis (Jones)
27 28 Cytheridea Mulleri (Jones)

Fig. 22 to 27 mag^d about 10 diameters.

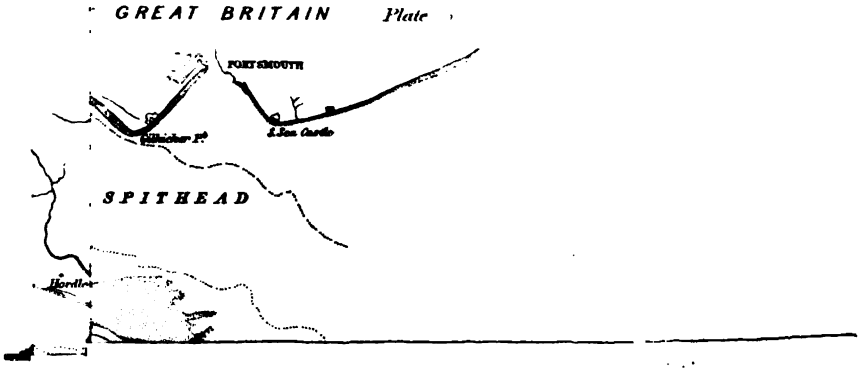


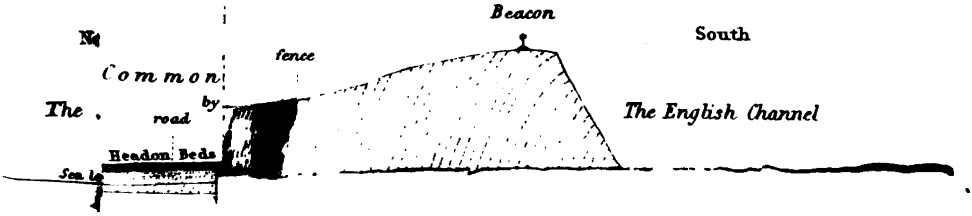
Plate 9.

R V E

near Wo

by Henr

Scale



Y OF G

Plate 10

Vertical Sectio

MIDDLE EOCE

By Edw.d Forbes

Rather ... *Shells much broken in the lower part)*
Green ... ventricosus, P. concavus, P. cinctus; Cyrena obovata, &c.
Ferru...
Bluish ... Ostrea (scattered)
Light ... ngiscata
VENUS ... *about 51° from the top: fossils chiefly*
Cythe... Ostrea, Cyrena obovata; Cytherea in-
Sang... ...
Varieg ...
centre
Dark ... *matter (lignite) bands full of*
White ... Potamides ventricosus;
Limes...
White
Blue ... ; Planorbis lens; P. euomphalus.
Purp...
Brow...
Sand
Bed o...
mas ... bivalves.
Pure ... *broken*.
... *no fossils.*
Dark
Light ... *bands: Chara; Paludina*
Curl...
Gree...
Lime ... Potamomya, Limnæa *(crushed)*
Gree...
Imp... Planorbis euomphalus; Paludina *(fragments)*
Light ... Limnæa longiscata, L. caudata
... *low*
Verb...
Lig...
Lig...
Dirt ... euomphalus; Paludina, Limnæa longiscata; Bithynia.
Sea ... cycladiformis; Potamides margaritaceus; P. duplex.
Green
Yellow

J. W. Lowry Sculpt.

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